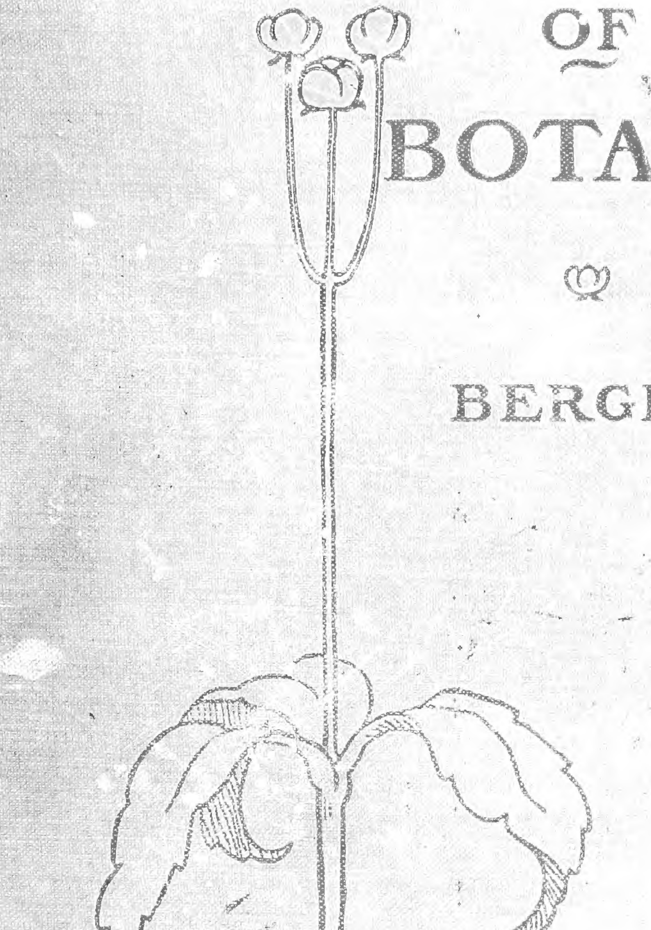
ESSENTIALS OF BOTANY



BERGEN

FRONTISPIECE. Pine Sap (*Monotropa Hypopitys*), a Saprophyte.

ESSENTIALS OF BOTANY

BY

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PREFACE

The favorable reception accorded to the author's revised *Elements of Botany* has led him to hope that a somewhat fuller book along the same lines might find a place. Accordingly the present work has been prepared especially for the use of secondary schools which devote a year to botany. It will also be found usable in schools which devote less than a year to the subject, but which prefer to spend on the study of spore-plants a considerable portion of the total time available for the science.

Chapters I–XXI will be found essentially identical with the first twenty-one chapters of the *Elements.* The matter in Chapters XXIII–XXVII relating to cryptogamic types has been rewritten and much extended. While the number of forms discussed is kept within moderate limits, it is believed that enough types are treated and that the presentation is sufficiently full to enable the pupil to realize that each of the higher plants is descended from a series of lower ones. Much detail in the discussion of plant evolution seems too difficult for most secondary schools.

The experience of a decade has shown that the study of ecology, except in the most elementary form, demands more kinds of knowledge and a better matured judgment than the beginner in botany can command. The teacher who wishes to do more with the subject than is suggested in the present book is referred to Part III of Bergen and Davis' *Laboratory and Field Manual of Botany.*

In deference to the wishes of many teachers, chapters on Plant Breeding, on Useful Plants, and on Timber and Forestry have been added. This matter may be used as a basis on which to build further reading for brief essays. Or it may suggest elementary investigations into the horticulture, the agriculture, or the forest conditions of the student's own neighborhood. The study of useful plants and their products may be taken up from Chapter XXX as the topics suggest themselves in earlier portions of the text, *i.e.*, seeds as food and medicine in connection with Chapter II, and so on.

The author wishes to thank Dr. A. A. Lawson, now of the University of Glasgow, Scotland, who read the manuscript of Chapters XXII–XXVII, for many valuable suggestions. Thanks are also due to Professor D. P. Penhallow of McGill University, Montreal, for suggestions on Chapter XXVIII, and to Dr. H. von Schrenk of St. Louis for aid on the chapter on Forestry.

Grateful acknowledgments are due for the use of illustrations copied for various figures as follows: D. H. Campbell, 208, 215; H. W. Conn, 170, 171, 175; W. G. Farlow, 160; A. E. Frye, 232, 234; C. F. Hodge, 225; A. D. Hopkins, 237; D. S. Jordan, 223; F. Roth, 236; J. H. Schaffner, 208; H. J. Webber, 224. Special mention should be made of the unpublished yucca drawing by Mrs. Grace Johnson Vieh, loaned by Professor William Trelease and used for Fig. 132. Some of the cuts above mentioned have been re-drawn, others are printed from the original wood engravings or zinc etchings.

A large proportion of the illustrations in Chapters XXIV–XXX have been re-drawn for the present book from the most authoritative sources by E. N. Fischer, F. S. Mathews, and C. H. L. Gebfert.

J. Y. B.

CAMBRIDGE, MASSACHUSETTS

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ESSENTIALS OF BOTANY

INTRODUCTION

Botany is the science of plants. It considers them as *individuals*, treating of their development, form, structure, and functions, and also as *dwellers in plant communities*, with complicated relations to each other and the world about them. One important division of the science, taxonomic botany, deals with plants as members of the plant kingdom and discusses their kinship, tracing their descent from remote common ancestors.

The study of botany may well begin with a rapid examination of one of the higher plants, to get an idea of its parts and their connection. Later on, some or all of the topics above suggested may be entered upon as fully as can be done in the time available for the entire subject of botany. Finally, a brief study may be undertaken of some of the uses of plants to man, that is, of the rudiments of economic botany.

The Nasturtium (Tropæolum).[1]

1. **The Entire Plant.** Dig up a plant so as to preserve most of the larger roots and wash the earth from them. Note the three sets of

[1] Any seed-plant of convenient size, with rather large and conspicuous flowers, will answer for this study. Some of the most available types for use at the beginning of the school year are *Petunia*, *Ipomœa*, *Salvia*, *Pelargonium*, *Impatiens*, *Mimulus*, *Linaria*, *Antirrhinum*.

parts or organs — *roots*, *stems*, and *leaves* — which make up the main bulk of what is known as the *plant body*.

Draw the plant body considerably reduced.

B. **Roots.** Note the origin and connections of the roots and state some of the main differences between roots and stems of this plant.

C. **Stem.** Select a portion of the stem with at least two well-grown leaves attached, and draw (reduced), showing how the leaf-stalks are attached. Describe how the stem branches. Cut off a bit and see whether it is solid or hollow. Split a small portion of it through the center and see if the stem appears to be of the same structure throughout and whether there is any bark or skin (*epidermis*) covering the exterior.

D. **Leaves.** Draw one of the largest leaves (reduced) and one or two of the smallest leaves (natural size). Include in the drawing the *leaf-stalks*. Describe how the leaf-stalk is attached to the expanded portion or *blade* of the leaf. Note where the principal *veins* originate and what course they take through the leaf-blade. Describe the principal differences between the upper and the under surface of the blade. If growing plants are at hand, try to make out how the tall kind of nasturtium climbs, that is, by what means it attaches itself to any convenient support. Study plants growing undisturbed and see whether the leaves are arranged at any definite angle with reference to the sun's rays (Plate IV).

The *vegetative organs* of the plant body, that is, the parts which it uses in the processes of life and growth, are the roots, stems, and leaves. Their functions are discussed in detail in special chapters, but here it may be stated that the roots serve to fasten the plant to the earth and to absorb from the soil water and dissolved materials useful in the nutrition of the plant; that the stem conducts water and plant foods and supports the leaves in a suitable position to do their work; and that the leaves perform most of the work of making plant food from the raw materials (which are derived from the air and the soil), and of respiration.

E. **The Flower.** Note that the stem bears flowers at intervals. Decide from what definite points they may arise. Make a reduced drawing of a short piece of stem with a leaf and a *flower-stalk*, bearing a flower. Draw (natural size) a side view of a flower with a bit of flower-stalk attached. Note that a *spur* extends backward from the flower nearly parallel to its stalk. Look at the outside and the inside of the flower to see how the rather leaf-like, bright-colored parts of which its principal bulk is made up are arranged with reference to each other. The five outer leaves, taken together, are called the *calyx*, and the five inner ones the *corolla*. Cut off the calyx leaves nearly at their bases, pull off the spur and all the corolla leaves, and draw the remaining organs more than natural size. Note that there are eight curved stalks, each of which bears a knob at its tip. These are called *stamens*. Decide whether all of the stamens mature at the same time. Within these is a much shorter object, divided at the tip into three portions. This is the *pistil*. See whether the stamens and the pistil mature at the same time.

F. **The Fruit.** Note that after the flowers wither all the parts except the pistil gradually fall off, and that the lower portion of the pistil finally develops into a green, three-lobed *fruit*. Cut across the largest and ripest fruit that can be obtained and ascertain how many *seeds* each lobe of the fruit contains.

The production of seed is the office of the flower, and the use of seeds is to reproduce the plant, since each perfect seed can under favorable circumstances grow into an individual like the parent plant. The formation of the seed is due to the action of *pollen*, a substance produced by the stamens. In some plants the pollen appears like fine dust, but in the majority of showy flowers, as in the nasturtium, it is a sticky, yellow, brownish, or reddish powder. The pollen acts in a very complicated way (Chapter XVI) on the rudimentary seeds borne within the base of the pistil, and causes them to develop into perfect seeds.

CHAPTER I

THE SEED AND ITS GERMINATION

1. Germination of the Squash Seed. — Soak some squash seeds in tepid water for twelve hours or more. Plant these about an inch deep in damp sand or pine sawdust or peat-moss in a wooden box which has had enough holes bored through the bottom so that it will not hold water. Put the box in a warm place (not at any time over 70° or 80° Fahrenheit),[1] and cover it loosely with a board or a pane of glass. Keep the sand or sawdust moist, but not wet, and the seeds will germinate. As soon as any of the seeds, on being dug up, are found to have burst open, sketch one in this condition,[2] noting the manner in which the outer seed-coat is split, and continue to examine the seedlings at intervals of two days, until at least eight stages in the growth of the plantlet have been noted.[3]

Observe particularly how the sand is pushed aside by the rise of the young seedlings. Suggest some reason for the manner in which the sand is penetrated by the rising stem.

2. Examination of the Squash Seed. — Make a sketch of the dry seed, natural size. Note the little scar at the pointed end of the

[1] Here and elsewhere throughout the book temperatures are expressed in Fahrenheit degrees, since with us, unfortunately, the Centigrade scale is not the familiar one outside of physical and chemical laboratories.

[2] The student need not feel that he is expected to make finished drawings to record what he sees, but some kind of careful sketch, if only the merest outline, is indispensable. Practice and study of the illustrations hereafter given will soon impart some facility even to those who have had little or no instruction in drawing. Consult here Figs. 2, 6, and 9.

[3] The class is not to wait for the completion of this work (which may, if desirable, be done by each pupil at home), but is to proceed at once with the examination of the squash seed, as directed in the following sections, and to set some corn to sprouting, so that it may be studied at the same time with the germinating squashes.

seed where the latter was attached to its place of growth in the squash. Label this *hilum*. Note the little hole in the hilum; it is the *micropyle*, seen most plainly in a soaked seed. (If there are two depressions on the hilum, the deeper one is the micropyle.)

Describe the color and texture of the outer coating of the seed. With a scalpel or a very sharp knife cut across near the middle a seed that has been soaked in water for twenty-four hours. Squeeze one of the portions, held edgewise between the thumb and finger, in such a way as to separate slightly the halves into which the contents of the seed is naturally divided. Examine with the magnifying glass the section thus treated, make a sketch of it, and label the shell or covering of the seed and the kernel within this.

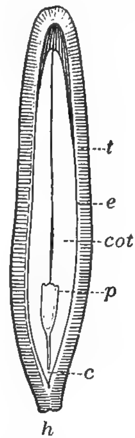


FIG. 1. Lengthwise Section of a Squash Seed. (Magnified about two and a half times.)

c, hypocotyl; *cot*, cotyledon; *e*, endosperm; *h*, hilum; *p*, plumule; *t*, testa.

Taking another soaked seed, chip away the white outer shell called the *testa*, and observe the thin, greenish inner skin (Fig. 1, *e*), with which the kernel of the seed is closely covered.[1]

Strip this off and sketch the uncovered kernel or *embryo*. Note that at one end it tapers to a point. This pointed portion, known as the *hypocotyl*, will develop after the seed sprouts into the stem of the plantlet, like that shown at *c* in Fig. 9.

Split the halves of the kernel entirely apart from each other, noticing that they are only attached for a very little way next to the hypocotyl, and observe the thickness of the halves and the slight unevenness of the inner surfaces. These halves are called seed-leaves or *cotyledons*.

Have ready some seeds which have been soaked for twenty-four hours and then left in a loosely covered jar on damp blotting paper at a temperature of 70° or over until they have begun to sprout.

Split one of these seeds apart, separating the cotyledons, and observe, at the junction of these, two very slender pointed objects, the rudimentary leaves of the *plumule* or first bud.

[1] See Sect. 15, page 13.

3. Examination of the Bean. — Study the seed, both dry and after twelve hours' soaking, in the same general way in which the squash seed has just been examined.[1]

Notice the presence of a distinct plumule, consisting of a pair of rudimentary leaves between the cotyledons, just where they are joined to the top of the hypocotyl. In many seeds (as the pea) the plumule does not show distinct leaves. But in all cases the plumule contains the *growing point*, the tip of the stem from which all the upward growth of the plant is to proceed.

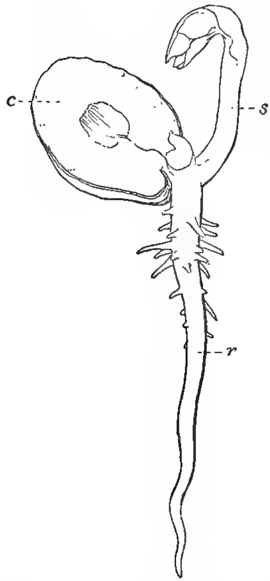


FIG. 2. Young Seedling of Windsor Bean.

c, cotyledon; r, root; s, stem.

Make a sketch of these leaves as they lie in place on one of the cotyledons after the bean has been split open.

Note the cavity in each cotyledon caused by the pressure of the plumule and of the hypocotyl.[2]

4. Germination of the Grain of Corn. — Soak some grains of corn and plant them as directed in Sect. 1.[3]

Make six or more sketches at various stages to illustrate the growth of the plumule and the formation of roots; first a main root from the base of the embryo, then others more slender from the same region, and later on still others from points higher up on the stem. The student may be able to discover what becomes of the large outer

[1] The larger the variety of bean chosen, the easier it will be to see and sketch the several parts. The large red kidney bean, the horticultural bean, or the Lima bean will do well for this examination.

[2] The teacher will find excellent sketches of most of the germinating seeds described in the present chapter in Newell's *Outlines of Lessons in Botany*, Part I.

[3] The pupil may economize space by planting the new seeds in boxes from which part of the earlier planted seeds have been dug up for use in sketching, etc.

part of the embryo. This is really the single cotyledon of the corn (Fig. 6). It does not as a whole rise above ground, but most of it remains in the buried grain and acts as a digesting and absorbing organ through which the *endosperm* or food stored outside of the embryo is transferred into the growing plant as fast as it can be made liquid for that purpose.

5. Conditions Requisite for Germination.—When we try to enumerate the external conditions which may affect germination, we find that the principal ones are heat, moisture, and presence of air. A few simple experiments will show what influence some of these conditions exert.

6. Temperature. — Common observation shows that a moderate amount of warmth is necessary for the sprouting of seeds. Every farmer or gardener knows that during a cold spring many seeds, if planted, will rot in the ground. But a somewhat exact experiment is necessary to show what is the best temperature for seeds to grow in, and whether variations in the temperature make more difference in the quickness with which they begin to germinate or in the total per cent which finally succeed.

EXPERIMENT I

Relation of Temperature to Germination. — Prepare at least four teacups or tumblers, each with wet soft paper packed in the bottom to a depth of nearly an inch. Have a tightly fitting cover over each. Put in each vessel the same number of soaked peas. Stand the vessels with their contents in places where they will be exposed to different, but fairly constant, temperatures, and observe the several temperatures carefully with a thermometer. Take pains to keep the tumblers in the warm places from drying out, so that their contents will not be less moist than that of the others. The following series is merely suggested, — other values may be found more convenient. Note the rate of germination in each place and record in tabular form as follows.

No. of seeds sprouted in	24 hrs.	48 hrs.	72 hrs.	96 hrs.	etc.
At 32°,	――	――	――	――	――
At 50°,	――	――	――	――	――
At 70°,	――	――	――	――	――
At 90°,[1]	――	――	――	――	――

7. Moisture. — What was said in the preceding section in regard to temperature applies also to the question of the best conditions for germination as regards the supply

FIG. 3. Soaked Peas in Stoppered Bottle, ready for Exhaustion of Air.

of moisture. The soil in which seeds grow out of doors is always moist; most kinds germinate best in earth not nearly saturated with moisture.

8. Relation of the Air Supply to Germination.— If we wish to see how soaked seeds will behave with hardly any air supply, it is necessary to place them in a bottle arranged

[1] For the exact regulation of the temperatures a thermostat (see Appendix II) is desirable. If one is available, a maximum temperature of 100° or over should be tried.

as shown in Fig. 3, exhaust the air by connecting the glass tube with an air-pump, which is then pumped vigorously, and seal the tube while the exhaustion is going on. The sealing is best done by holding a Bunsen flame under the middle of the horizontal part of the tube. A much easier experiment, which is nearly as satisfactory, can, however, be performed without the air-pump.

EXPERIMENT II

Will Seeds Germinate well without a Good Supply of Air? — Place some soaked seeds on damp blotting paper in the bottom of a bottle, using seeds enough to fill it three-quarters full, and close tightly with a rubber stopper.

Place a few other seeds of the same kind in a second bottle; cover loosely.

Place the bottles side by side so that they will have the same conditions of light and heat. Watch for results and tabulate as in previous experiments.

Most seeds will not germinate under water, but those of the sunflower will do so, and therefore Exp. II may be varied in the following manner.

Remove the shells carefully from a considerable number of sunflower seeds.[1] Try to germinate one lot of these in water which has been boiled in a flask to remove the air, and then cooled in the same flask. Over the water, with the seeds in it, a layer of cotton-seed oil about a half inch deep is poured, to keep the water from contact with air. In this bottle then there will be only seeds and air-free water. Try to germinate another lot of seeds in a bottle half filled with ordinary water, also covered with cotton-seed oil. Results?

9. Germination involves Chemical Changes. — If a thermometer is inserted into a jar of sprouting seeds, for

[1] These are really fruits, but the distinction is not an important one at this time.

instance peas, in a room at the ordinary temperature, the peas will be found to be warmer than the surrounding air. This rise of temperature is at least partly due to the absorption from the air of that substance in it which supports the life of animals and maintains the burning of fires, namely, *oxygen.*

The union of oxygen with substances with which it can combine, that is with those which will burn, is called *oxidation.* This kind of chemical change is universal in plants and animals while they are in an active condition, and the energy which they manifest in their growth and movements is as directly the result of the oxidation going on inside them as the energy of a steam engine is the result of the burning of coal or other fuel under its boiler. In the sprouting seed much of the energy produced by the action of oxygen upon oxidizable portions of its contents is expended in producing growth, but some of this energy is wasted by being transformed into heat which escapes into the surrounding soil. It is this escaping heat which is detected by a thermometer thrust into a quantity of germinating seeds.

EXPERIMENT III

Effect of Germinating Seeds upon the Surrounding Air. — When Exp. II has been finished, remove a little of the air from above the peas in the first bottle. This can easily be done with a rubber bulb attached to a short glass tube. Then bubble this air through some clear, filtered limewater. Also blow the breath through some limewater by aid of a short glass tube. Explain any similarity in results obtained. (Carbon dioxide turns limewater milky.) Afterwards insert into the air above the peas in the same bottle a lighted pine splinter, and note the effect upon its flame.

10. Other Proofs of Chemical Action. — Besides the proof of chemical changes in germinating seeds just described, there are other kinds of evidence to the same effect.

Malt, which is merely sprouted barley with its germination permanently stopped at the desired point by the application of heat, tastes differently from the unsprouted grain, and can be shown by chemical tests to have suffered a variety of changes. If you can get unsprouted barley and malt, taste both and see if you can decide what substance is more abundant in the malt.

Germinating kernels of corn undergo great alterations in their structure; the starch grains are gradually eaten away until they are ragged and full of holes and finally disappear.

11. The Embryo and its Development. — The miniature plant, as it exists ready formed and alive but inactive in the seed, is called the *embryo*. In the seeds so far examined, practically the entire contents of the seed-coats consist of the embryo, but this is not the case with the great majority of seeds, as will be shown in the following chapter.

CHAPTER II

STORAGE OF FOOD IN THE SEED

12. Food in the Embryo. — Squash seeds are not much used for human food, though both these and melon seeds are occasionally eaten in parts of Europe; but beans and peas are important articles of food. Whether the material accumulated in the cotyledons is an aid to the growth of the young plant may be learned from a simple experiment.

13. Mutilated and Perfect Seedlings. — One of the best ways in which to find out the importance and the special use of any part of a plant is to remove the part in question and see how the plant behaves afterward.

EXPERIMENT IV[1]

Are the Cotyledons of a Pea of any Use to the Seedling? — Sprout several peas on blotting paper. When the plumules appear, carefully cut away the cotyledons from some of the seeds. Place on a perforated cork, as shown in Fig. 4, one or two seedlings from which the cotyledons have been cut, and as many which have not been mutilated, and allow the roots to extend into the water. Let them grow for some days, or even weeks, and note results.

14 Storage of Food outside of the Embryo. — In very many cases the cotyledons contain little food, but there is a supply of it stored in the seed beside or around them (Figs. 5 and 6).

[1] May be a home experiment.

15. Examination of the Four-o'clock Seed. — Examine the external surface of a seed[1] of the four-o'clock, and try the hardness of the outer coat by cutting it with a knife. From seeds which have been soaked in water at least twenty-four hours peel off the coatings and sketch the kernel. Make a cross-section of one of the soaked seeds which has not been stripped of its coatings, and sketch the section, as seen with the magnifying glass, to show the parts, especially the two cotyledons, lying in close contact and encircling the white, starchy-looking *endosperm*.[2]

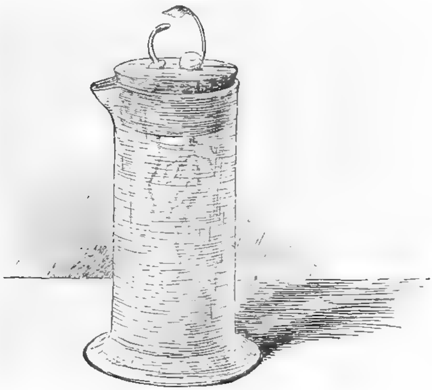


FIG. 4. Germinating Peas, growing in Water, one deprived of its Cotyledons.

The name *endosperm* is applied to food stored in parts of the seed other than the embryo.[3] With a mounted needle pick out the little almost spherical mass of endosperm from inside the cotyledons of a seed which has been deprived of its coats, and sketch the embryo, noting how it is curved so as to enclose the endosperm almost completely.

16. Examination of the Kernel of Indian Corn. — Soak some grains of large yellow field corn[4] for about three days.

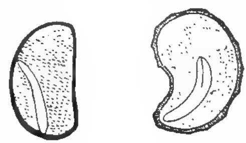


FIG. 5. Seeds with Endosperm, Longitudinal Sections.

I, asparagus (magnified).
II, poppy (magnified).

[1] Strictly speaking, a fruit.

[2] Buckwheat furnishes another excellent study in seeds with endosperm. Like that of the four-o'clock, it is, strictly speaking, a fruit; so also is a grain of corn.

[3] Reserve food derived from the part of the ovule (*nucellus*) just outside of the embryo sac (Fig. 124) is called *perisperm*.

[4] The varieties with long, flat kernels, raised in the Middle and Southern States under the name of "dent corn," are the best.

Sketch an unsoaked kernel so as to show the grooved side where the germ lies. Observe how this groove has become partially filled up in the soaked kernels.

Remove the thin, tough skin from one of the latter and notice its transparency. This skin — the bran of unsifted corn meal — does not exactly correspond to the testa and inner coat of ordinary seeds, since the kernel of corn, like all other grains (and like the seed of the four-o'clock), represents not merely the seed, but also the seed-vessel in which it was formed and grew, and is therefore a fruit.

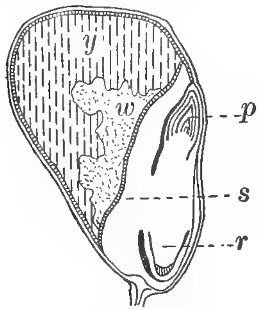


Fig. 6. Lengthwise Section of Grain of Corn. (Magnified about three times.)

y, yellow, oily part of endosperm; *w*, white, starchy part of endosperm; *p*, plumule; *s*, the shield (cotyledon), in contact with the endosperm for absorption of food from it; *r*, the primary root.

Cut sections of the soaked kernels, some transverse, some lengthwise and parallel to the flat surfaces, some lengthwise and at right angles to the flat surfaces. Try the effect of staining some of these sections with iodine solution.

Make a sketch of one section of each of the three kinds, and label the dirty white portion of cheesy consistency, *embryo;* and the yellow portions and those which are white and floury, *endosperm.*

Chip off the endosperm from one kernel so as to remove the embryo free from other parts.[1] Notice its form, somewhat triangular in outline, sometimes nearly the shape of a beechnut, in other specimens nearly like an almond.

Estimate what proportion of the entire bulk of the soaked kernel is embryo.

Split the embryo lengthwise so as to show the slender, somewhat conical plumule.[2]

[1] The embryo may be removed with great ease from kernels of rather mature green corn. Boil the corn for about twenty minutes on the cob, then pick the kernels off one by one with the point of a knife. They may be preserved indefinitely in alcohol of 50% or 75%.

[2] The teacher may well consult Figs. 56–61, inclusive, in Gray's *Structural Botany.*

17. Starch. — Most common seeds contain starch. Every one knows something about the appearance of ordinary commercial starch as used in the laundry and as sold for food in packages of cornstarch. When pure it is characterized not only by its lustre, but also by its peculiar velvety feeling when rubbed between the fingers.

18. The Starch Test. — It is not always easy to recognize at sight the presence of starch as it occurs in seeds, but it may be detected by a very simple chemical test, namely, the addition of a solution of iodine.[1]

EXPERIMENT V[2]

Examination of Familiar Seeds with Iodine. — Cut in two with a sharp knife the seeds to be experimented on, then pour on each, drop by drop, some of the iodine solution. Only a little is necessary; sometimes the first drop is enough.

If starch is present, a blue color (sometimes almost black) will appear. If no color is obtained in this way, boil the pulverized seeds for a moment in a few drops of water, and try again.

Test in this manner corn, wheat (in the shape of flour), oats (in oatmeal), barley, rice, buckwheat, flax, rye, sunflower, four-o'clock, morning-glory, mustard seed, beans, peanuts, Brazil-nuts, hazelnuts, and any other seeds that you can get. Report your results in tabular form as follows.

Much Starch	Little Starch	No Starch
Color: blackish or dark blue	Color: pale blue or greenish	Color: brown, orange, or yellowish

[1] The tincture of iodine sold at the drug-stores will do, but the solution prepared as directed in the *Handbook* answers better. This may be made up in quantity and issued to the pupils in drachm vials, to be taken home and used there if the experimenting must be done outside of the laboratory or the schoolroom.

[2] May be a home experiment.

19. Microscopical Examination of Starch.[1] — Examine starch in water with a rather high power of the microscope (not less than 200 diameters).

Pulp scraped from a potato, that from a canna rootstock, wheat flour, the finely powdered starch sold under the commercial name of "cornstarch" for cooking, oatmeal, and buckwheat finely powdered in a mortar, will furnish excellent examples of the shape and markings of starch grains. Sketch all of the kinds examined, taking pains to bring out the markings.[2] Compare the sketches with Figs. 7 and 8.

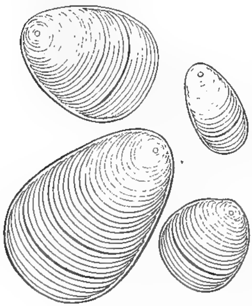


FIG. 7. Canna Starch. (Magnified 300 diameters.)

With a medicine-dropper or a very small pipette run a drop of iodine solution under one edge of the cover-glass, at the same time withdrawing a little water from the margin opposite by touching to it a bit of blotting paper. Examine again and note the blue coloration of the starch grains and the unstained or yellow appearance of other substances in the field. Cut very thin slices from beans, peas, or kernels of corn; mount in water, stain as above directed, and draw as seen under the microscope. Compare with Figs. 7 and 8.[3] Note the fact that the starch is not packed away in the seeds in bulk, but that it is enclosed in little chambers or *cells*.

20. Plant-Cells. — Almost all the parts of the higher plants are built up of little separate portions called *cells*. The cell is the unit of plant-structure, and bears something

[1] At this point the teacher should give a brief illustrated talk on the construction and theory of the compound microscope.

[2] The markings will be seen more distinctly if care is taken not to admit too much light to the object. Rotate the diaphragm beneath the stage of the microscope, or otherwise regulate the supply of light, until the opening is found which gives the best effect.

[3] The differentiation between the starch grains, the other cell-contents, and the cell-walls will appear better in the drawings if the starch grains are sketched with blue ink.

the same relation to the plant of which it is a part that one cell of a honeycomb does to the whole comb. Cells are of all shapes and sizes, from little spheres a ten-thousandth of an inch or less in diameter to slender tubes, such as fibers of cotton, several inches long. To get an idea of the appearance of some rather large cells, scrape a little pulp from a ripe, mealy apple, and examine it first

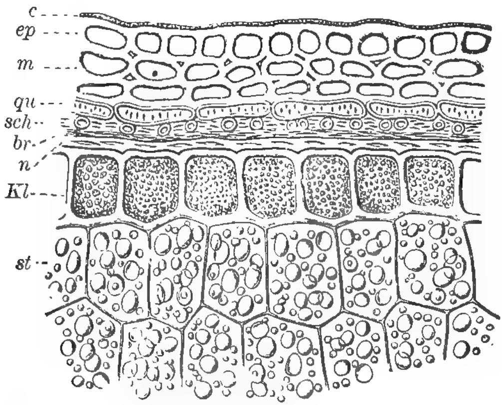


FIG. 8. Section through Exterior Part of a Grain of Wheat.

c, cuticle or outer layer of bran; *ep*, epidermis; *m*, layer beneath epidermis; *qu*, *sch*, layers of hull next to seed-coats; *br*, *n*, seed-coats; *Kl*, layer containing proteid grains; *st*, cells of the endosperm filled with starch. (Greatly magnified.)

with a strong magnifying glass, then with a moderate power of the compound microscope. To see how dead, dry cell-walls with nothing inside them look, examine (as before) a very thin slice of elder pith, sunflower pith, or pith from a dead cornstalk. Look also at the figures in Chapter VII of this book. Notice that the simplest plants (Chapter XXIII) consist of a single cell each. The study of the structure of plants is the study of the forms which cells and groups of cells assume, and the study of plant physiology is the study of what cells and cell combinations do.

21. Absorption of Starch from the Cotyledons. — Examine with the microscope, using a medium power, soaked beans and the cotyledons from seedlings that have been growing for three or four weeks. Stain the sections with iodine solution, and notice how completely the clusters of starch grains that filled most of the cells of the unsprouted cotyledons have disappeared from the shriveled cotyledons of the seedlings. A few grains may be left, but they have lost their sharpness of outline.

22. Oil. — The presence of oil in any considerable quantity in seeds is not as general as is the presence of starch, though in many common seeds there is a good deal of it.

Sometimes the oil is sufficiently abundant to make it worth while to extract it by pressure, as is done with flaxseed, cotton-seed, the seeds of some plants of the cress family, the "castor bean" and other seeds.

23. Dissolving Oil from Ground Seeds. — It is not easily possible to show a class how oil is extracted from seeds by pressure; but there are several liquids which readily dissolve oils and yet have no effect on starch and most of the other constituents of seeds.

EXPERIMENT VI

Extraction of Oil by Ether or Benzine. — To a few ounces of ground flaxseed add an equal volume of ether or benzine. Let it stand ten or fifteen minutes and then filter. Let the liquid stand in a saucer or evaporating dish in a good draught till it has lost the odor of the ether or benzine.

Describe the oil which you have obtained.

Of what use would it have been to the plant?

If the student wishes to perform this experiment at home for himself, he should bear in mind the following.

Caution. — Never handle benzine or ether near a flame or stove.

A much simpler experiment to find oil in seeds may readily be performed by the pupil at home. Put the material to be studied, *e.g.*, flaxseed meal, corn meal, wheat flour, cotton-seed meal, buckwheat flour, oatmeal, and so on, upon little labeled pieces of white paper, one kind of flour or meal on each bit of paper. Place all the papers, with their contents, on a perfectly clean plate, free from cracks, or on a clean sheet of iron, and put this in an oven hot enough nearly (but not quite) to scorch the paper. After half an hour remove the plate from the oven, shake off the flour or meal from each paper, and note the results, a more or less distinct grease spot showing the presence of oil, or the absence of any stain showing that there was little or no oil in the seed examined.

24. Albuminous Substances. — Albuminous substances or *proteids* occur in all seeds, though often only in small quantities. They have nearly the same chemical composition as white of egg and the curd of milk among animal substances, and are essential to the plant, since the living and growing parts of all plants contain large quantities of proteid material.

Sometimes the albuminous constituents of the seed occur in more or less regular grains (Fig. 8, *Kl*). But much of the proteid material of seeds is not in any form in which it can be recognized under the microscope. One test for its presence is the peculiar smell which it produces in burning. Hair, wool, feathers, leather, and lean meat all produce a well-known sickening smell when scorched or burned, and the similarity of the proteid material in such seeds as the bean and pea to these substances is shown by the fact that scorching beans and similar seeds give off the familiar smell of burnt feathers.

25. Chemical Tests for Proteids. — All proteids (and very few other substances) are turned yellow by nitric acid, and this yellow color becomes deeper or even orange when the yellowish substance is moistened with ammonia. They are also turned yellow by iodine solution.

EXPERIMENT VII

Detection of Proteids in Seeds. — Extract the germs from some soaked kernels of corn and bruise them; soak some wheat-germ meal for a few hours in warm water, or wash the starch out of wheat-flour dough; reserving the latter for use, place it in a white saucer or porcelain evaporating dish and moisten well with nitric acid; examine after fifteen minutes.

26. The Brazil-Nut as a Typical Oily Seed. — Not many familiar seeds are as oily as the Brazil-nut. Its large size makes it convenient for examination, and the fact that this nut is good for human food makes it the more interesting to investigate the kinds of plant-food which it contains.

EXPERIMENT VIII

Testing Brazil-Nuts for Plant-Foods. — Crack fifteen or twenty Brazil-nuts, peel off the brown coating from the kernel of each, and then grind the kernels to a pulp in a mortar. Shake up this pulp with ether, pour upon a paper filter, and wash with ether until the washings when evaporated are nearly free from oil. The funnel containing the filter should be kept covered as much as possible until the washing is finished. Evaporate the filtrate to procure the oil, which may afterwards be kept in a glass-stoppered bottle. Dry the powder which remains on the filter and keep it in a wide-mouthed bottle. Test portions of this powder for proteids and for starch. Explain the results obtained.

27. Other Constituents of Seeds. — Besides the substances above suggested, others occur in different seeds. Some of these are of use in feeding the seedling, others are of value in protecting the seed itself from being eaten by animals or in rendering it less liable to decay. In such seeds as that of the nutmeg, the essential oil which gives it its characteristic flavor probably makes it unpalatable to animals and at the same time preserves it from decay.

Date seeds are so hard and tough that they cannot be eaten and do not readily decay. Lemon, orange, horse-chestnut, and buckeye seeds are too bitter to be eaten, and the seeds of the apple, cherry, peach, and plum are somewhat bitter.

The seeds of larkspur, thorn-apple,[1] croton, the castor-oil plant, nux vomica, and many other kinds of plants contain active poisons.

[1] Datura, commonly called "Jimson weed."

CHAPTER III

MOVEMENTS, DEVELOPMENT, AND MORPHOLOGY OF THE SEEDLING

28. How the Seedling emerges. — As the student has already learned by his own observations, the seedling does not always push its way straight out of the ground. Corn, like all the other grains and grasses, it is true, sends a tightly rolled, pointed leaf vertically upward into the air. But the other seedlings examined usually will not be found to do anything of the sort. The squash seedling is a good one in which to study what may be called the arched hypocotyl type of germination. If the seed when planted is laid horizontally on one of its broad surfaces, it usually goes through some such changes of position as are shown in Fig. 9.

The seed is gradually tilted until at the time of their emergence from the ground the cotyledons are almost vertical. The only part above the ground-line at this period is the arched hypocotyl. Once out of ground, the cotyledons soon rise until they are again vertical, but with the ends farthest from the hypocotyl at the top. Then the two cotyledons separate until they once more lie horizontal, pointing away from each other.

Can you suggest any advantage which the plant derives from having the cotyledons dragged out of the ground rather than having them pushed out, tips first?

29. What pushes the Cotyledons up? — A very little study of any set of squash seedlings is sufficient to show that the portion of the plant where roots and hypocotyl are joined neither rises nor sinks, but that the plant grows both ways from this part. It is evident that as soon as the hypocotyl begins to lengthen much it must do one of two things: either push the cotyledons out into the air or else force the root down into the ground as one might push a stake down. What

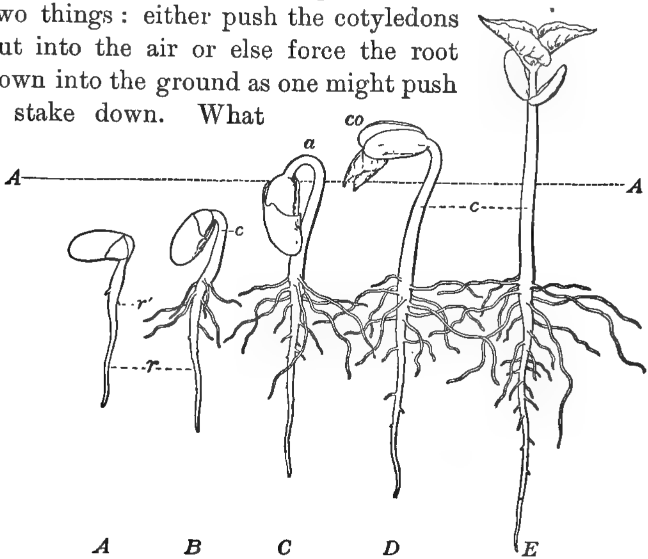


FIG. 9. Successive Stages in the Life History of the Bean Seedling.

AA, the surface of the ground; *r*, primary root; *r′*, secondary root; *c*, hypocotyl; *a*, arch of hypocotyl; *co*, cotyledons.

changes does the plantlet undergo in passing from the stage shown at *A* to that of *B* and of *C*, making it harder and harder for the root to be thrust downward?

30. Use of the Peg. — Squash seedlings usually (though not always) form a sort of knob on the hypocotyl. This is known as the *peg*. Study a good many seedlings and try to find out what the lengthening of the hypocotyl, between the peg and the bases of the cotyledons, does for the little plant. Set a lot of squash seeds, hilum down, in moist sand or sawdust and see whether the peg is more or less developed than in seeds sprouted lying on their sides, and whether the cotyledons in the case of the vertically planted seeds usually come out of the ground in the same condition as do others.

31. Disposition made of the Cotyledons. — The cotyledons of the squash during the growth of the seedling increase greatly in surface, acquire a green color and a generally leaf-like appearance, and, in fact, do the work of ordinary leaves. In such a case as this the appropriateness of the name *seed-leaf* is evident enough,—one recognizes at sight the fact that the cotyledons are actually the plant's first leaves. In the bean the leaf-like nature of the cotyledons is not so clear. They rise out of the ground like the squash cotyledons, but then gradually shrivel away, though they may first turn green and somewhat leaf-like for a time.

The development of the plumule seems to depend somewhat on that of the cotyledons. The squash seed has cotyledons which are not too thick to become useful leaves, and so the plant is in no special haste to get ready any other leaves. The plumule, therefore, cannot readily be found in the unsprouted seed, and is almost microscopic in size at the time when the hypocotyl begins to show outside of the seed-coats.

32. Root, Stem, and Leaf. — By the time the seedling is well out of the ground it usually possesses the three kinds of *vegetative organs*, or parts essential to growth, of ordinary flowering plants, *i.e.*, the root, stem, and leaf, or, as they are sometimes classified, root and shoot. All of these organs may multiply and increase in size as the plant grows older, and their mature structure will be studied in later chapters, but some facts concerning them can best be learned by watching their growth from the outset.

33. Elongation of the Root. — We know that the roots of seedlings grow pretty rapidly from the fact that each day finds them reaching visibly farther down into the water or other medium in which they are planted. A sprouted Windsor bean in a vertical thistle-tube will send its root downward fast enough so that ten minutes' watching through the microscope will suffice to show growth. To find out just where the growth goes on requires a special experiment.

EXPERIMENT IX

In what Portions of the Root does its Increase in Length take place? — Sprout some peas on moist blotting paper in a loosely covered tumbler. When the roots are one and a half inches or more long, mark them along the whole length with little dots made with a bristle dipped in water-proof India ink, or a fine inked thread stretched on a little bow of whalebone or brass wire.

Transfer the plants to moist blotting paper under a bell-glass or an inverted battery jar and examine the roots at the end of twenty-four hours to see along what portions their length has increased; continue observations on them for several days.

34. Root-Hairs. — Barley, oats, wheat, red clover, or buckwheat seeds soaked and then sprouted on moist blotting paper afford convenient material for studying *root-hairs.* The seeds may be kept covered with a watch-glass or a clock-glass while sprouting. After they have begun to germinate well care must be taken not to have them kept in too moist an atmosphere, or very few root-hairs will be formed. Examine with the magnifying glass those parts of the root which have these appendages.

Try to find out whether all the portions of the root are equally covered with hairs, and, if not, where they are most abundant (see also Fig. 10).

The root-hairs in plants growing under ordinary conditions are surrounded by the moist soil and wrap themselves around microscopical particles of earth (Fig. 11). Thus they are able to absorb rapidly through their thin walls the soil-water with whatever mineral substances it has dissolved in it.

35. The Young Stem. — The hypocotyl, or portion of the stem which lies below the cotyledons, is the earliest formed portion of the stem. Sometimes this lengthens but little, as in Fig. 2; often, however, as the student knows from his own observations, the hypocotyl lengthens enough to raise the cotyledons well above ground, as in Fig. 9.

The later portions of the stem are considered to be divided into successive *nodes* (places at which a leaf, or a scale which represents a leaf, appears) and *internodes* (portions between the leaves).

The student should watch the growth of a seedling bean or pea and ascertain by actual measurements whether the internodes lengthen after they have once been formed, and, if so, for how long a time the increase continues.

36. The First Leaves. — The cotyledons are, as already explained, the first leaves which the seedling possesses, — even if a plumule is found well developed in the seed, it was formed after the cotyledons. In those plants which have so much food stored in the cotyledons as to render these unfit ever to become useful foliage leaves, there is little or nothing in the color, shape, or general appearance of the cotyledon to make one think it really a leaf, and it is only by studying many cases that the botanist is enabled to class all cotyledons as leaves in their nature, even if they are quite unable to do the ordinary work of leaves. The

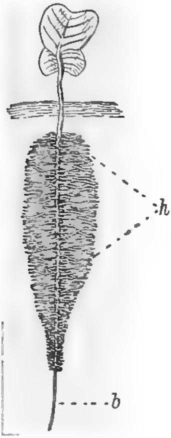


Fig. 10.

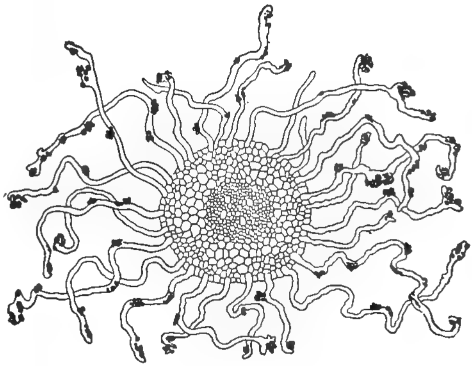


Fig. 11.

Fig. 10. A Turnip Seedling, with the Cotyledons developed into Temporary Leaves.

h, root-hairs from the primary root; *b*, bare portion of the root on which no hairs have as yet been produced.

Fig. 11. Cross-Section of a Root.

A good deal magnified, showing root-hairs attached to particles of soil, and sometimes enwrapping these particles.

study of the various forms which the parts or organs of a plant may assume is called *morphology;* it traces the relationship of parts which are really akin to each other, though dissimilar in appearance and often in function. In seeds which have endosperm, or other food outside of the embryo, the cotyledons usually become green and leaf-like, as they do, for example, in the four-o'clock, the morning-glory, and the buckwheat; but in the seeds of the grains (which contain endosperm) a large portion of the single cotyledon remains throughout as a thickish mass buried in the seed. In a few cases, as in the pea, there are scales instead of true leaves formed on the first nodes above the cotyledons, and it is only at about the third node above that leaves of the ordinary kind appear.

FIG. 12. Germinating Pine.

co, cotyledons.

In the bean and some other plants which in general bear one leaf at a node along the stem there is a pair produced at the first node above the cotyledons, and the leaves of this pair differ in shape from those which arise from the succeeding portions of the stem.

37. Classification of Plants by the Number of their Cotyledons. — In the pine family the germinating seed often displays more than two cotyledons, as shown in Fig. 12; in the majority of common flowering plants the seed contains two cotyledons, while in the lilies, the rushes, the sedges, the grasses, and some other plants there is but one cotyledon. Upon these facts is based the division of most flowering plants into two great groups: the *dicotyledonous plants*, which have two seed-leaves, and the *monocotyledonous plants*, which have one seed-leaf. Other important differences nearly always accompany the difference in number of cotyledons, as will be seen later.

38. Tabular Review of Experiments. — Make out a table containing a very brief summary of the experiments thus far performed, as follows.

NUMBER OF EXPERIMENT	OBJECT SOUGHT	MATERIALS AND APPARATUS	OPERATIONS PERFORMED	RESULTS	INFERENCES

CHAPTER IV

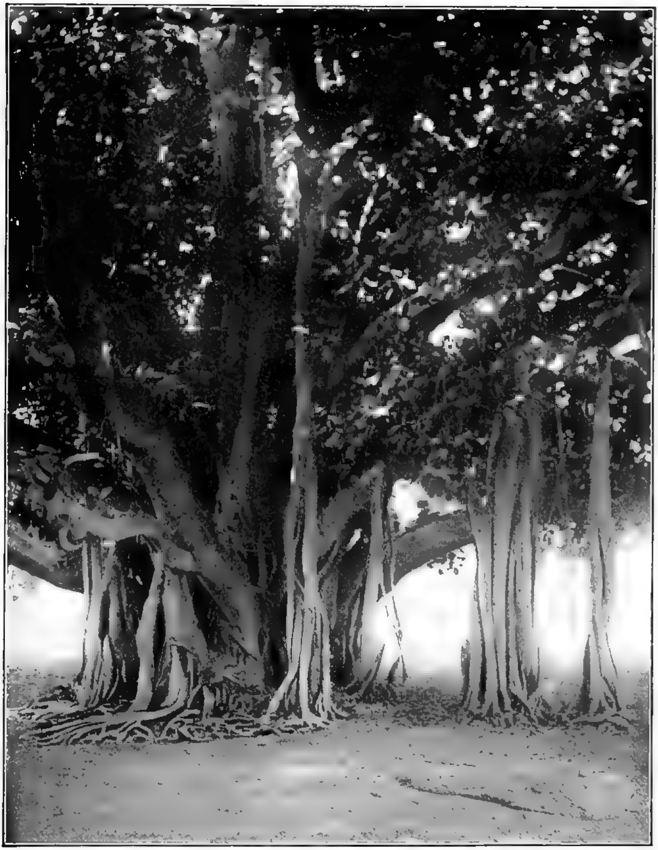
ROOTS[1]

39. Origin of Roots. — The *primary root* originates from the lower end of the hypocotyl, as the student learned from his own observations on sprouting seeds. The branches of the primary root are called *secondary roots*, and the branches of these are known as *tertiary roots.* Those roots which occur on the stem or in other unusual places are known as *adventitious roots.* The roots which form so readily on cuttings of willow, southernwood, tropæolum, French marigold, geranium (pelargonium), tradescantia, and many other plants, when placed in damp earth or water, are adventitious.

40. Aërial Roots. — While the roots of most familiar plants grow in the earth and are known as *soil-roots*, there are others which are formed in the air, called *aërial roots.* They serve various purposes: in some tropical air-plants often cultivated they fasten the plant to the tree on which it establishes itself, and they also take in water which drips from branches and trunks above them, so that these plants require no soil and grow in mid-air suspended from trees, which serve them merely as supports;[2] many such

[1] To the plant the root is more important than the stem. The author has, however, treated the structure of the latter more fully than that of the root, mainly because the tissues are more varied in the stem and a moderate knowledge of the more complex anatomy of the stem will serve every purpose.

[2] If it can be conveniently managed, the class will find it highly interesting and profitable to visit any greenhouse of considerable size in which the aërial roots of orchids and aroids may be examined.



Photograph by Robert Cameron.

Plate I. Aërial Roots of a Banyan Tree.

air-plants are grown in greenhouses. In such plants as the ivy (Fig. 13) the aërial roots (which are also adventitious) hold the plant to the wall or other surface up which it climbs.

In the Indian corn roots are sent out from nodes at some distance above the ground and finally descend until they

FIG. 13. Aërial Adventitious Roots of the Ivy.

enter the ground. They serve both to anchor the cornstalk so as to enable it to resist the wind and to supply additional water to the plant.[1] They often produce no rootlets until they reach the ground.

41. Water-Roots. — Many plants, such as the willow, readily adapt their roots to live either in earth or in water, and some, like the little floating duckweed, regularly produce

[1] Specimens of the lower part of the cornstalk, with ordinary roots and aërial roots, should be dried and kept for class study.

roots which are adapted to live in water only. These water-roots often show large and distinct sheaths on the ends of the roots, as, for instance, in the so-called water-hyacinth. This plant is especially interesting for laboratory cultivation from the fact that it may readily be transferred to moderately damp soil, and that the whole plant presents curious modifications when made to grow in earth instead of water.

42. Parasitic Roots.[1] — The dodder, the mistletoe, and a good many other *parasites* live upon nourishment which they steal from other plants called *hosts*. The parasitic roots, or *haustoria*, form the most intimate connections with the interior portions of the stem or the root, as the case may be, of the host-plant on which the parasite fastens itself.

In the dodder, as is shown in Fig. 14, it is most interesting to notice how admirably the seedling parasite is adapted to the conditions under which it is to live. Rooted at first in the ground, it develops a slender, leafless stem, which, leaning this way and that, no sooner comes into permanent contact with a congenial host than it produces haustoria at many points, gives up further growth in its soil-roots, and grows rapidly on the strength of the supplies of ready-made sap which it obtains from the host.

43. Forms of Roots. — The primary root is that which proceeds like a downward prolongation directly from the lower end of the hypocotyl. In many cases the mature root-system of the plant contains one main root much larger than any of its branches. This is called a *taproot* (Fig. 15).

Such a root, if much thickened, would assume the form shown in the carrot, parsnip, beet, turnip, salsify, or radish, and is called a fleshy root. Some plants produce *multiple*

[1] See Kerner and Oliver's *Natural History of Plants*, Vol. I, pp. 171–213.

primary roots, that is, a cluster proceeding from the lower end of the hypocotyl at the outset. If such roots become thickened, like those of the sweet potato and the dahlia (Fig. 17), they are known as *fascicled roots*.

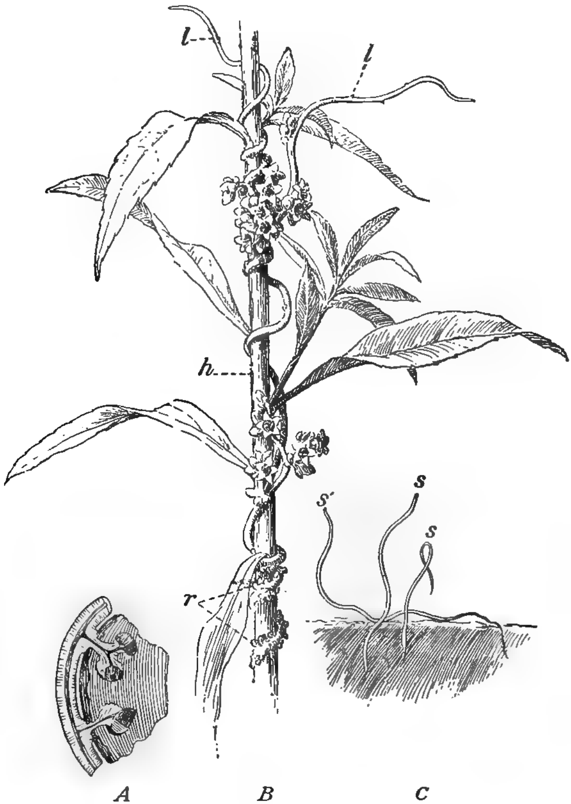


Fig. 14. Dodder growing upon a Golden-Rod Stem.

s, seedling dodder plants, growing in earth; *h*, stem of host; *r*, haustoria or parasitic roots of dodder; *l*, scale-like leaves; *A*, magnified section of a portion of willow stem, showing penetration of haustoria.

Roots of grass, etc., are thread-like, and known as *fibrous roots* (Fig. 16).

44. General Structure of Roots. — The structure of the very young root can be partially made out by examining the entire root with a moderate magnifying power, since

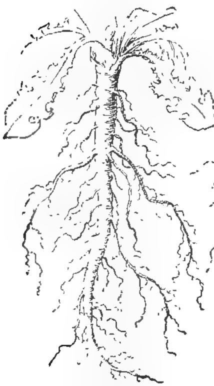


FIG. 15.
A Taproot.

FIG. 16.
Fibrous Roots.

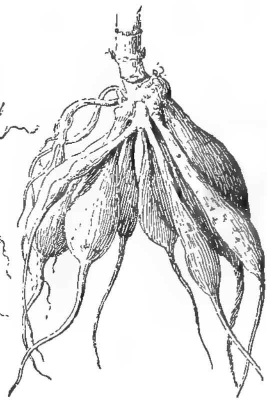


FIG. 17.
Fascicled Roots.

the whole is sufficiently translucent to allow the interior as well as the exterior portion to be studied while the root is still alive and growing. Earth roots will not do for this, since the adhering particles are opaque and hide the structures beneath.

Place some vigorous cuttings of tradescantia or *Zebrina*, which can usually be obtained of a gardener or florist, in a beaker or jar of water.[1] The jar should be as thin and transparent as possible, and it is well to get a flat-sided rather than a cylindrical one. Leave the jar of cuttings in a sunny, warm place. As soon as roots have

[1] If the tradescantia or *Zebrina* cannot be obtained, roots of seedlings of oats, wheat, or barley, or of red-clover seedlings raised in a large covered cell on a microscope slide, may be used.

developed at the nodes and reached the length of three-quarters of an inch or more, arrange a microscope in a horizontal position (see *Handbook*) and examine the tip and adjacent portion of one of the young roots with a power of from twelve to twenty diameters.

Note:

(*a*) The root-cap, of loosely attached cells.

(*b*) The central cylinder.

(*c*) The cortical portion, a tubular part enclosing the solid central cylinder.

(*d*) The root-hairs, which cover some parts of the outer layer of the cortical portion very thickly. Observe particularly how far toward the tip of the root the root-hairs extend, and where the youngest ones are found.

Make a drawing to illustrate all the points above suggested (*a*, *b*, *c*, *d*). Compare your drawing with Fig. 18. Make a careful study of longitudinal sections through the centers of the tips of very young roots of the hyacinth or the Chinese sacred lily. Sketch one section and compare the sketch with Fig. 18.

Make a study of the roots of any of the common duckweeds, growing in a nutrient solution in a jar of water under a bell-glass, and note the curious root-pockets which here take the place of root-caps.

45. Details of Root-Structure. — The plan on which the young root is built has been outlined in Sect. 44. A few further particulars are necessary to an understanding of how the root does its work. On examining Fig. 19, the cylinders of which the root is made up are easily distinguished, and the main constituent parts of each can be made out without much trouble. The epidermis-cells are seen to be somewhat brick-shaped, many of them provided with extensions into root-hairs. Inside the epidermis lie several layers of rather globular, thin-walled cells, and inside these a boundary layer between the cortical or bark portion of the root and the central cylinder. This latter region is especially marked by the presence of certain groups of cells, shown at *w* and *d* and at *b*, the two former serving as channels for air and water, the latter (and *w* also) giving toughness to the root.

Roots of shrubs and trees more than a year old will be found to have increased in thickness by the process described in Sect. 88, and a section may look quite unlike the young root-section shown in Fig. 19.

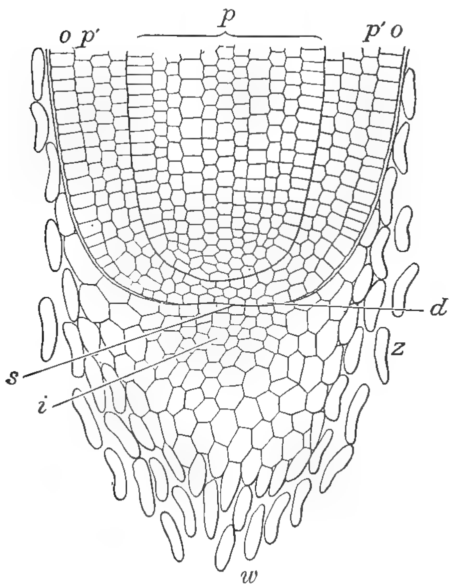


Fig. 18. Lengthwise Section (somewhat diagrammatic) through Root-Tip of Indian Corn. × about 130.

w, root-cap; *i*, younger part of cap; *z*, dead cells separating from cap; *s*, growing point; *o*, epidermis; *p′*, intermediate layer between epidermis and central cylinder; *p*, central cylinder; *d*, layer from which the root-cap originates.

46. Examination of the Root of a Shrub or Tree. — Cut thin transverse sections of large and small roots of any hardwood tree[1] and examine them first with a low power of the microscope, as a two-inch objective, to get the general disposition of the parts, then with a higher power, as the half-inch or quarter-inch, for details. With the low power, note:

(*a*) The brown layer of outer bark.

(*b*) The paler layer within this.

(*c*) The woody cylinder which forms the central portion of the root.

[1] Young suckers of cherry, apple, etc., which may be pulled up by the roots, will afford excellent material.

The distinction between (*b*) and (*c*) is more evident when the section has been exposed to the air for a few minutes and changed somewhat in color.

47. Structure and Contents of a Fleshy Root. — In some fleshy roots, such as the beet, the morphology of the parts is rather puzzling, since they form many layers of tissue in a single season, showing on the cross-section of the root a series of layers which look a little like the annual rings of trees.

The structure of the turnip, radish, carrot, and parsnip is simpler.

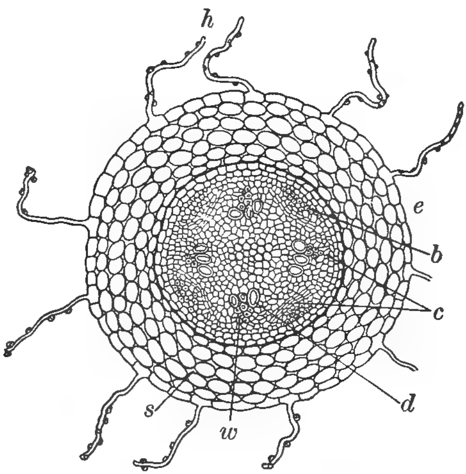


FIG. 19. Much Magnified Cross-Section of a very Young Dicotyledonous Root.

h, root-hairs with adhering bits of sand; *e*, epidermis; *s*, thin-walled, nearly globular, cells of bark; *b*, hard bast; *c*, cambium; *w*, wood-cells; *d*, ducts.

Cut a parsnip across a good deal below the middle, and stand the cut end in eosin solution for twenty-four hours.

Then examine by slicing off successive portions from the upper end. Sketch some of the sections thus made. Cut one parsnip lengthwise and sketch the section obtained. In what portion of the root did the colored liquid rise most readily? The ring of red marks the boundary between the cortical portion and the central cylinder. To which does the main bulk of the parsnip belong? Cut thin transverse sections from an ink-stained parsnip and in those sections that show it, find out where the secondary roots arise. If possible, peel off the cortical portion from one stained root and leave the central cylinder with the secondary roots attached. Stain one section with iodine and sketch it. Where is the starch of this root mainly stored?

Test some bits of parsnip for proteids by boiling them for a minute or two with strong nitric acid.

What kind of plant-food does the taste of cooked parsnips show them to contain? [On no account taste the bits which have been boiled in the poisonous nitric acid.]

48. Storage in Other Roots. — The parsnip is by no means a remarkable plant in its capacity for root-storage. The roots of the yam and the sweet potato contain a good deal of sugar and much more starch than is found in the parsnip. Beet-roots contain so much sugar that a large part of the sugar supply of Europe and an increasing portion of our own supply is obtained from them. Oftentimes the bulk of a fleshy root is exceedingly large as compared with that of the parts of the plant above ground.

A good example of this occurs in a plant,[1] related to the morning-glory and the sweet potato, found in the south-eastern United States, which has a root of forty or fifty pounds weight.

Not infrequently roots have a bitter or nauseous taste, as in the case of the chicory, the dandelion, and the rhubarb, and a good many, like the monkshood, the yellow jasmine, and the pinkroot, are poisonous. Can you give any reason why the plant may be benefited by the disgusting taste or poisonous nature of its roots?

49. Use of the Food stored in Fleshy Roots. — The parsnip, beet, carrot, and turnip are *biennial plants;* that is, they do not produce seed until the second summer or fall after they are planted.

[1] *Ipomœa Jalapa.*

The first season's work consists mainly in producing the food which is stored in the roots. To such storage is due their characteristic fleshy appearance. If this root is planted in the following spring, it feeds the rapidly growing stem which proceeds from the bud at its summit, and an abundant crop of flowers and seed soon follows; while the root, if examined in late summer, will be found to be withered, with its store of reserve material quite exhausted.

The roots of the dahlia (Fig. 17), the sweet potato, and a multitude of other *perennials*, or plants which live for many years, contain much stored plant-food. Many such plants die to the ground at the beginning of winter, and in spring make a rapid growth from the materials laid up in the roots.

50. Extent of the Root-System. — The total length of the roots of ordinary plants is much greater than is usually supposed. They are so closely packed in the earth that only a few of the roots are seen at a time during the process of transplanting, and when a plant is pulled or dug up in the ordinary way a large part of the whole mass of roots is broken off and left behind. A few plants have been carefully studied to ascertain the total weight and length of the roots. Those of winter wheat have been found to extend to a depth of seven feet. By weighing the whole root-system of a plant and then weighing a known length of a root of average diameter, the total length of the roots may be estimated. In this way the roots of an oat plant have been calculated to measure about 154 feet; that is, all the roots, if cut off and strung together end to end, would reach that distance.

51. Absorption of Water by Roots. — Many experiments on the cultivation of corn, wheat, oats, beans, peas, and other familiar plants in water have proved that some plants, at any rate, can thrive very well on ordinary lake, river, or well water, together with the food which they absorb from the air (Chapter XIII). Just how much water some kinds of plants give off (and therefore absorb) per day will be discussed when the uses of the leaf are studied. For the present it is sufficient to state that even an annual plant during its lifetime absorbs through the roots very many times its own weight of water. Grasses have been known to take in their weight of water in every twenty-four hours of warm, dry weather. This absorption takes place mainly through the root-hairs, which the student has examined as they occur in the seedling plant, and which are found thickly clothing the younger and more rapidly growing parts of the roots of mature plants. Some idea of their abundance may be gathered from the fact that on a rootlet of corn grown in a damp atmosphere, and about $\frac{1}{17}$ inch in diameter, 480 root-hairs have been counted on each hundredth of an inch in length. The walls of the root-hairs are extremely thin, and they are free from any holes or pores which can be seen even by the highest power of the microscope, yet the water of the soil penetrates very rapidly to the interior of the root-hairs. The soil-water brings with it all the substances which it can dissolve from the earth about the plant; and the closeness with which the root-hairs cling to the particles of soil, as shown in Fig. 19, must cause the water which is absorbed to contain more foreign matter than underground water in general does, particularly since the roots give off enough weak acid from their surface to corrode the surface of stones which they enfold or cover.

52. Movements of Young Roots. — The fact that roots usually grow downward is so familiar that we do not generally think of it as a thing that needs discussion or explanation. Since they are pretty flexible, it may seem as though young and slender roots merely hung down by their own weight, like so many bits of wet cotton twine. But a very little experimenting will answer the question whether this is really the case. Making fine equidistant cross-marks with ink along the upper and the lower surface of a root that is about to bend downward at the tip readily shows that those of the upper series soon come to be farther apart, — in other words, that *the root is forced to bend downward by the more rapid growth of its upper as compared with its under surface.*

53. Direction taken by Secondary Roots. — As the student has already noticed in the seedlings which he has studied, the branches of the primary root usually make a considerable angle with it. Often they run out for long distances almost horizontally. This is especially common in the roots of forest trees, above all in cone-bearing trees, such as pines and hemlocks. This horizontal or nearly horizontal position of large secondary roots is the most advantageous arrangement to make them useful in staying or guying the stem above to prevent it from being blown over by the wind.

54. Fitness of the Root for its Position and Work. — The distribution of material in the woody roots of trees and shrubs and their behavior in the soil show many adaptations to the conditions by which the roots are surrounded. The growing tip of the root, as it pushes its way through the soil, is exposed to bruises; but these are largely warded off by the root-cap. The tip also shows a remarkable sensitiveness to contact with hard objects, so that when touched by one it swerves aside and thus finds its way downward by the easiest path. Roots with an unequal water supply on either side grow toward the moister soil. Roots are very tough, because they need to resist strong pulls, but not as stiff as stems and branches of the same size, because they do not need to withstand sidewise pressure, acting from one side only. The corky layer which covers the outsides of roots is remarkable for its power of preventing evaporation. It must be of use in retaining in the root the moisture which otherwise might be lost on its way from the deeper rootlets (which are buried in damp soil) through the upper portions of the root-system, about which the soil is often very dry.

55. Propagation by Means of Roots. — Some familiar plants, such as rose bushes, are usually grown from roots or root-cuttings.

Bury a sweet potato or a dahlia root in damp sand and watch the development of sprouts from adventitious buds. One sweet potato will produce several such crops of sprouts, and every sprout may be made to grow into a new plant. It is in this way that the crop is started wherever the sweet potato is grown for the market.

56. Review Summary of Roots.

Kinds of roots as regards origin	{
Kinds as regards medium in which they grow .	{
Structure of root of a tree.	
Storage in roots	materials. location. uses.
Absorption of water by roots	apparatus. amount.
Movements of roots	nature. causes. uses.

CHAPTER V

PLANT-CELLS; SOME FUNCTIONS OF CELLS IN THE ROOT

57. Structure of a Plant-Cell. — Plants are made up of elementary organs called *cells*. These are small (usually microscopic) objects of many different shapes and subserve various purposes in the life of the plant. The simplest plants of all consist of but a single cell, which may have any one of a great variety of shapes, but is often nearly spherical. The higher plants, such as all the flowering plants, consist of hundreds of thousands or millions of cells each, and the total number in a large tree is inconceivably great.

A single cell taken from the tip of a growing shoot of any of the higher plants, when much magnified, is seen to consist of a cell-wall (*w*, Fig. 20) filled with a more or less liquid substance known as *protoplasm*. A large part of the bulk of this protoplasm consists of a roundish object *n*, called the *nucleus*, and inside this is a more opaque body *nc*, called the *nucleolus*. As the cell grows the protoplasm is soon found to separate

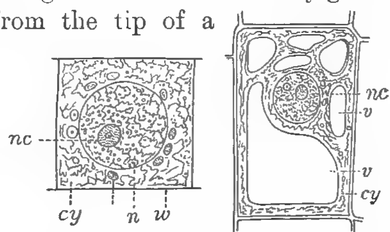


FIG. 20. Two rapidly Growing Cells (both greatly magnified, *A* twice as much as *B*). *A* is a very young cell in which the protoplasm does not as yet show vacuoles. *B* is older, with several vacuoles; *n*, nucleus; *nc*, nucleolus; *cy*, protoplasm or cytoplasm; *v*, vacuoles; *w*, cell-wall.

into mucilaginous or jelly-like portions and watery enclosed droplets known as *vacuoles*. The liquid which constitutes the vacuoles is called *cell-sap*.

The cell-wall is made of a substance called *cellulose*, which is familiar to every one in the form of cotton. A bit of cotton wool is nearly pure cellulose. Chemically it is a very inactive substance, and its main use as a part of the cell is to form a tough covering for it through which liquids can readily soak in or out.

58. Characteristics of Living Protoplasm.[1] — The protoplasm is the active part of every cell and all the work of the plant is done by the cell protoplasm, generally in the higher plants, by the coöperation of many thousands of *protoplasts* (as the little protoplasmic units are called). The remarkable powers which belong to living protoplasm have been summed up as follows.

(1) The power to take up new material into its own substance (*selective absorption*). This is not merely a process of soaking up liquids, as a sponge absorbs water. The protoplasmic lining of a root-hair, for example, selects from the soil-water some substances and rejects others.

(2) The ability to change certain substances into others of different chemical composition (*assimilation* or *metastasis*, Sect. 166). The way in which the stored plant-food of seeds is changed into the materials of the young seedling (Sects. 9, 10) is an example of assimilative action exerted by special cells in and adjoining the embryo. Many other instances occur.

(3) The power to cast off waste or used-up material (*excretion*). Getting rid of surplus water and of oxygen constitutes a very large part of the excretory work of plants.

[1] See Huxley's *Essays*, Vol. I, essay on *The Physical Basis of Life*.

(4) The capacity for growth and the production of offspring (*reproduction*). These are especially characteristic of living protoplasm.

(5) The possession of the power of originating movements not wholly and directly caused by any external impulse (*automatic movements*). Such, for instance, are the lashing movements of the cilia of minute plants and spores, Figs. 157, 169.

(6) The power of shrinking or closing up (*contractility*).

(7) Sensitiveness when touched or otherwise disturbed. This is shown by insect-catching leaves (Sect. 140), by the leaves of sensitive plants, and parts of certain flowers.

The most remarkable and peculiar of the characteristics of protoplasm as above given are due to its possessing *irritability*. By this is meant the power to respond in some definite way to any suitable ***stimulus*** or exciting cause, acting from within or without the plant body. Some of the principal stimuli are gravity, heat, light, chemical substances, and contact with solid objects.

59. Osmosis. — In order to understand the selective absorption which constitutes a large part of the work of the roots of plants it is necessary first to study ***osmosis***. This is the process by which two liquids separated by membranes pass through the latter and mingle.

It is readily demonstrated by experiments with thin animal or vegetable membranes.

EXPERIMENT X

Osmosis as shown in an Egg. — Cement to the smaller end of an egg a bit of glass tubing about six inches long and about three-sixteenths of an inch inside diameter. Sealing-wax or a mixture of equal parts of beeswax and resin melted together will serve for a cement.

Chip away part of the shell from the larger end of the egg, place it in a wide-mouthed bottle or a small beaker full of water, as shown in Fig. 21, then very cautiously pierce a hole through the upper end of the eggshell by pushing a knitting-needle or wire down through the glass tube.

Watch the apparatus for some hours and note any change in the contents of the tube. Explain.

The rise of liquid in the tube is evidently due to water making its way through the thin membrane which lines the eggshell, although this membrane contains no pores visible even under the microscope.

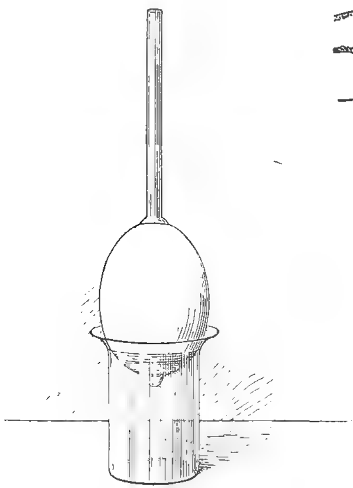


FIG. 21. Egg on Beaker of Water, to show Osmosis.

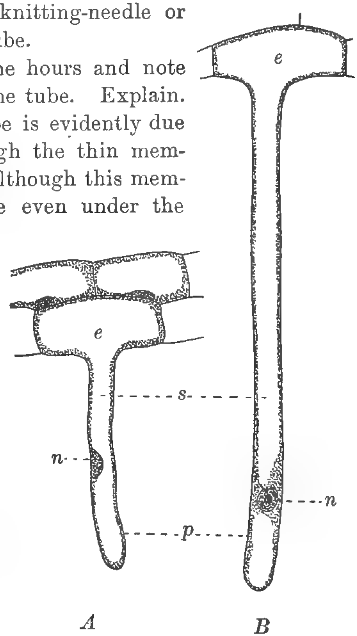


FIG. 22.

A, a very young root-hair; *B*, a much older one (both greatly magnified). *e*, cells of the epidermis of the root; *n*, nucleus; *s*, watery cell-sap; *p*, thicker protoplasm lining the cell-wall.

60. Osmosis in Root-Hairs. — The soil-water (practically identical with ordinary spring or well water) is separated from the more or less sugary or mucilaginous sap inside of the root-hairs only by their delicate cell-walls lined with a thin layer of protoplasm (Fig. 22). This soil-water will pass rapidly into the plant, while very little of the sap will come out. The selective action, which causes the flow of liquid through the root-hairs to be almost wholly inward, is due to the living layer of protoplasm, which covers the inner surface of the cell-wall of the root-hair. When the student has learned how active a substance protoplasm often shows itself to be, he will not be astonished to find it behaving almost as though it were possessed of intelligence and will. Traveling by osmotic action from cell to cell, a current of water derived from the root-hairs is forced up through the roots and into the stem, just as the contents of the egg was forced up into the tube shown in Fig. 21.

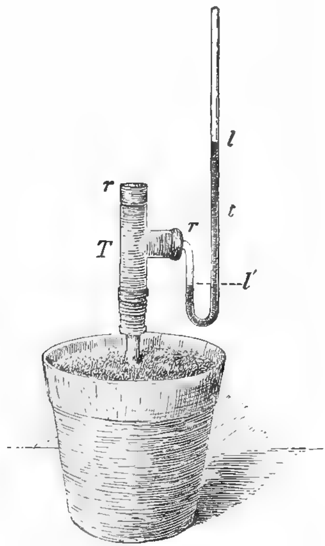


Fig. 23. Apparatus to measure Sap-Pressure.

T, large tube fastened to the stump of the dahlia stem by a rubber tube; *r r*, rubber stoppers; *t*, bent tube containing mercury; *l l′*, upper and lower level of mercury in *T*.

61. Sap-Pressure. — The force with which the upward-flowing current of water presses may be estimated by attaching a mercury gauge to the root of a tree or the stem of a small sapling. This is best done in early spring after the thawing of the ground but before the leaves have appeared. The experiment may also be performed indoors upon almost any plant with a moderately firm stem through which the water from the soil rises freely. A dahlia plant or a tomato plant answers well, though the sap-pressure from one of these will not be nearly as great as that from a larger shrub or a tree growing out of doors. In Fig. 23 the apparatus is shown attached to the stem of a dahlia. The difference of level of the mercury in the bent tube serves to measure the sap-pressure. For every foot of difference in level there must be a pressure of nearly six pounds per square inch on the stump at the base of the tube *T*.[1]

A black-birch root tested in this way at the end of April has given a root-pressure of thirty-seven pounds to the square inch. This would sustain a column of water about eighty-six feet high.

[1] See Appendix II.

CHAPTER VI

STEMS

62. What the Stem is. — The work of taking in the raw materials which the plant makes into its own food is done mainly by the roots and the leaves. These raw materials are taken from earth, from water, and from the air (see Chapter XIII). The stem is that part or organ of the plant which serves to bring roots and leaves into communication with each other. In most flowering plants the stem also serves the important purpose of lifting the leaves up into the sunlight where alone they can best do their special work.

The student has already, in Chapter III, learned something of the development of the stem and the seedling; he has now to study the external appearance and internal structure of the mature stem. Much in regard to this form and structure can conveniently be learned from the examination of twigs and branches of our common forest trees in their winter condition.

63. The Horse-Chestnut Twig.[1] — Procure a twig of horse-chestnut eighteen inches or more in length. Make a careful sketch of it, trying to bring out the following points.

(1) The general character of the bark.

[1] Where the buckeye is more readily obtained it will do very well. Hickory twigs answer the same purpose, and the latter is a more typical form, having alternate buds. The magnolia or the tulip tree will do. The student should (sooner or later) examine at least one opposite- and one alternate-leaved twig.

(2) The large horseshoe-shaped scars and the number and position of the dots on these scars. Compare a scar with the base of a leaf-stalk furnished by the teacher.

(3) The ring of narrow scars around the stem in one or more places,[1] and the different appearance of the bark above and below such a ring. Compare these scars with those left after removing the scales of a terminal bud.

(4) The buds at the upper margin of each leaf-scar and the strong terminal bud at the end of the twig.

(5) The flower-bud scar, a concave impression, to be found in the angle produced by the forking of two twigs, which form, with the branch from which they spring, a Y-shaped figure.

(6) (On a branch larger than the twig handed round for individual study) the place of origin of the twigs on the branch. Make a separate sketch of this.

The portion of stem which originally bore any pair of leaves is called a *node*, and the portions of stem between nodes are called *internodes*.

Describe briefly in writing alongside the sketches any observed facts which the drawings do not show.

If your twig was a crooked, rough-barked, and slow-growing one, exchange it for a smooth, vigorous one, and note the differences. Or if you sketched a quickly grown shoot, exchange for one of the other kind.

Answer the following questions:

(*a*) How many inches did your twig grow during the last summer?
How many in the summer before?
How do you know?
How many years old is the whole twig given you?

(*b*) How were the leaves arranged on the twig?
How many leaves were there?
Were they all of the same size?

(*c*) What has the mode of branching to do with the arrangement of the leaves? with the flower-bud scars?

(*d*) The dots on the leaf-scars mark the position of the bundles of ducts and wood-cells which run from the wood of the branch through the leaf-stalk up into the leaf.

[1] A very vigorous shoot may not show any such ring.

64. Twig of Poplar. — Sketch a vigorous young twig of poplar (or of hickory, magnolia, tulip tree) in its winter condition, noting particularly the respects in which it differs from the horse-chestnut. Describe in writing any facts not shown in the sketch. Notice that the buds are not opposite, nor is the next one above any given bud found directly above it, but part way round the stem from the position of the first one. Ascertain, by studying several twigs and counting around, which bud is above the first and how many turns round the stem are made in passing from the first to the one directly above it.

Observe with especial care the difference between the poplar and the horse-chestnut in mode of branching, as shown in a large branch provided for the study of this feature.

65. Relation of Leaf Arrangement to Branching.[1] — This difference depends on the fact that the leaves of the horse-chestnut were arranged in pairs on opposite sides of the stem, while those of the poplar were not in pairs. Since the buds are found at the upper edges of the leaf-scars, and since most of the buds of the horse-chestnut and the poplar are leaf-buds and destined to form branches, the mode of branching and ultimately the form of the tree must depend largely on the arrangement of leaves along the stem.

66. Opposite Branching. — In trees, the leaves and buds of which are opposite, the tendency will be to form twigs in four rows about at right angles to each other along the sides of the branch, as shown in Fig. 24.

This arrangement will not usually be perfectly carried out, since some of the buds may never grow, or some may

[1] The teacher in the Eastern and Middle States will do well to make constant use, in the study of branches and buds, of Newell's *Outlines of Lessons in Botany*, Part I. The student can observe for himself, with a little guidance from the teacher, most of the points which Miss Newell suggests. If the supply of material is abundant, the twigs employed in the lessons above described need not be used further, but if material is scanty, the study of buds may at once be taken up. (See also Bailey's *Lessons with Plants*, Part I.)

grow much faster than others and so make the plan of branching less evident than it would be if all grew alike.

67. Alternate Branching. — In trees like the beech the twigs will be found to be arranged in a more or less regular spiral line about the branch. This, which is known as the *alternate* arrangement (Fig. 25), is more commonly met with in trees and shrubs than the *opposite* arrangement. It admits of many varieties, since the spiral may wind more or less rapidly round the stem. In the apple, pear, cherry, poplar, oak, and walnut, one passes over five spaces before coming to a leaf which is over the first, and in doing this it is necessary to make two complete turns round the stem.

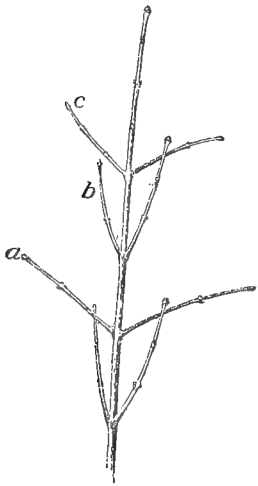


Fig. 24. Opposite Branching in a very Young Sapling of Ash.

Fig. 25. Alternate Branching in a very Young Apple Tree.

68. Growth of the Terminal Bud. — In some trees the terminal bud from the very outset keeps the leading place, and the result of this mode of growth is to produce a slender, upright tree, with an *excurrent* trunk like that of Fig. 232. In such trees as the apple and many oaks the terminal bud has no preëminence over others, and the form of the tree is round-topped and spreading, *deliquescent* like that in Fig. 235.

Most of the larger forest trees are intermediate between these extremes.

Branches get their characteristics to a considerable degree from the relative importance of their terminal buds. If these are mainly flower-buds, as is the case in the horse-chestnut, the tree is characterized by frequent forking, and has no long horizontal branches.

If the terminal bud keeps the lead of the lateral ones, but the latter are numerous and most of them grow into

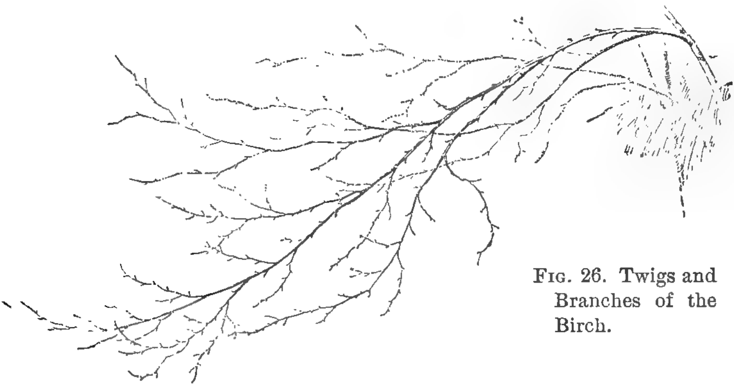


Fig. 26. Twigs and Branches of the Birch.

slender twigs, the delicate spray of the elm and many birches is produced (Fig. 26).

The general effect of the branching depends much upon the angle which each branch or twig forms with that one from which it springs. The angle may be quite acute, as in the birch, or more nearly a right angle, as in the ash (Fig. 24).

It is these differences that help to give to leafless woods in winter their unending variety and beauty.

69. Indefinite Annual Growth. — In most of the forest trees, and in the larger shrubs, the wood of the branches is matured and fully developed during the summer, and protected buds are formed on the twigs to their very tips. In other shrubs — for example, in the sumac, the raspberry, and blackberry — the shoots continue to grow until their soft and partly matured tips are killed by the frost. Such a mode of growth is called *indefinite annual growth*, to distinguish it from the *definite annual growth* of most trees.

70. Trees, Shrubs, and Herbs. — Plants of the largest size, with a main trunk of a woody structure, are called *trees*. *Shrubs* differ from trees in their smaller size, and generally in their more forking and divided stem. The witch-hazel, the dogwoods, and the alders, for instance, are most of them classed as shrubs for this reason, though in height some of them equal the smaller trees. Some of the smallest shrubby plants, like the blueberry, the wintergreen, and the trailing arbutus, are only a few inches in height, but are ranked as shrubs because their woody stems do not die quite to the ground in winter.

Herbs are plants whose stems above ground die every winter.

71. Annual, Biennial, and Perennial Plants. — *Annual* plants are those which live but one year, *biennials* those which live nearly or quite two years.

Some annual plants may be made to live over winter, flowering in their second summer. This is true of winter wheat and rye among cultivated plants.

Perennial plants live for a series of years. Many kinds of trees last for centuries. The Californian giant redwoods, or Sequoias, which reach a height of over 300 feet under favorable circumstances, live nearly 2000 years; and some very large cypress trees found in Mexico were thought by Professor Asa Gray to be from 4000 to 5000 years old.

72. "Stemless Plants."— The so-called *stemless plants*, like the dandelion (Fig. 27) and some violets, are not really stemless at all, but send out their leaves and flowers from a very short stem which hardly rises above the surface of the ground.

FIG. 27. The Dandelion; a so-called Stemless Plant.

Now, as will be shown later (Chapter XXI), plants live subject to a very fierce competition among themselves and exposed to almost constant attacks from animals.

Any plant which can grow in safety under the very feet of grazing animals will be especially likely to make its way in the world, since there are many places where it can flourish while ordinary plants would be destroyed. The bitter, stemless dandelion, which is almost uneatable for most animals, unless cooked, which lies too near the earth to be fed upon by grazing animals, and which bears being trodden on with impunity, is a type of a large class of hardy weeds. And while plants with long stems find it to their account to reach up as far as possible into the sunlight, the cinquefoil, the white clover, the dandelion, the spurges, the knot-grass, and hundreds of other kinds of plants have found safety in hugging the ground.

73. Climbing and Twining Stems.[1] — Since it is essential to the health and rapid growth of most plants that they should have free access to the sun and air, it is not strange that many should resort to special devices for lifting themselves above their neighbors. In tropical forests, where the darkness of the shade anywhere beneath the tree-tops is so great that few flowering plants can thrive in it, the climbing plants, or *lianas*, often run like great cables for hundreds of feet before they can emerge into the sunshine above, and share the light with the trees which support them. In temperate climates no such remarkable climbers are found, but many plants raise themselves for considerable distances. The principal means to which they resort for this purpose are:

FIG. 28. Coiling of a Tendril of Bryony.

(1) Producing roots at many points along the stem above ground and climbing on suitable objects by means of these, as in the English ivy (Fig. 13).

(2) Laying hold of objects by means of tendrils or *twining* branches or *leaf-stalks* (Figs. 28, 29).

(3) Twining about any slender upright support (Fig. 30).

[1] See Kerner and Oliver's *Natural History of Plants*, Vol. I, p. 669.

74. Tendril-Climbers. — The plants which climb by means of tendrils are very interesting subjects for study, but they cannot usually be managed very well in the schoolroom. Continued observation soon shows that the tips of tendrils sweep slowly about in the air until they come in contact with some object about which they can coil themselves. After the tendril has taken a few turns about its support, the free part of the tendril coils into a spiral and thus draws the whole stem toward the point of attachment, as shown in Fig. 28. Some tendrils are leaves or stipules, others are modified stems.

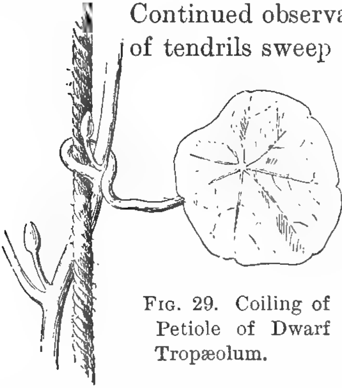


Fig. 29. Coiling of Petiole of Dwarf Tropæolum.

75. Twiners.[1] — Only a few of the upper internodes of the stem of a twiner are concerned in producing the movements of the tip of the stem. This is kept revolving in an elliptical or circular path until it encounters some roughish and not too stout object about which it then proceeds to coil itself. The direction of the coiling varies in different kinds of climbers, some following the course shown in the figure

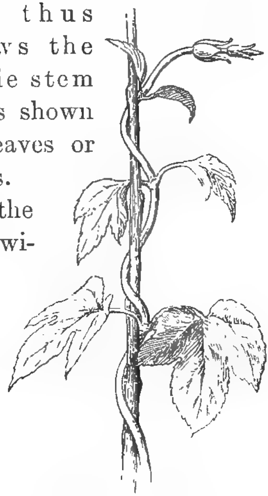


Fig. 30. Twining Stem of Hop.

[1] See article on *Climbing Plants*, by Dr. W. J. Beal, in the *American Naturalist*, Vol. IV, pp. 405–415.

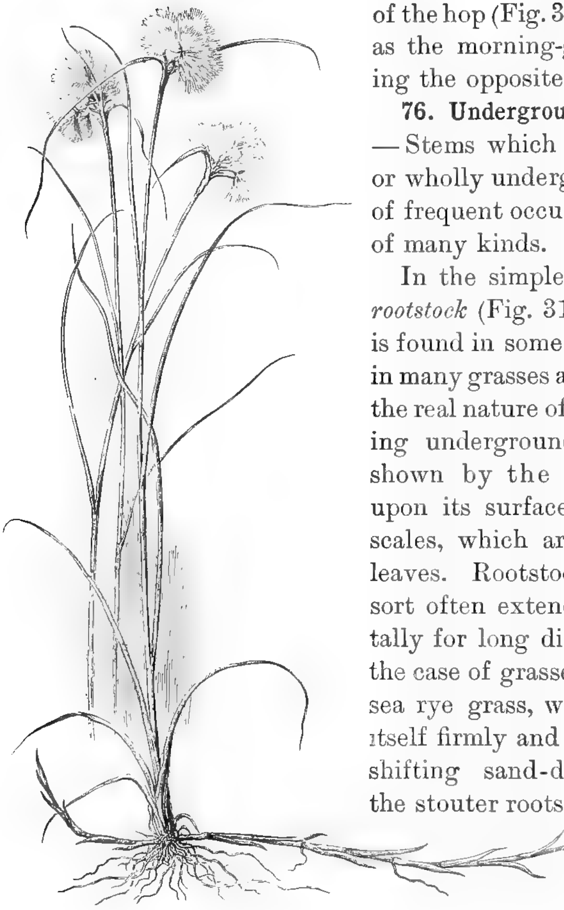


Fig. 31. Rootstock of Cotton-Grass (*Eriophorum*).

of the hop (Fig. 30); others, as the morning-glory, taking the opposite course.[1]

76. Underground Stems. — Stems which lie mainly or wholly underground are of frequent occurrence and of many kinds.

In the simplest form of *rootstock* (Fig. 31), such as is found in some mints and in many grasses and sedges, the real nature of the creeping underground stem is shown by the presence upon its surface of many scales, which are reduced leaves. Rootstocks of this sort often extend horizontally for long distances in the case of grasses like the sea rye grass, which roots itself firmly and thrives in shifting sand-dunes. In the stouter rootstocks, like that of the iris (Fig. 32) and the

[1] See Strasburger, Noll, Schenk, and Karsten's *Text-Book*, pp. 257–260; also Vines, *Students' Text-Book of Botany*, London and New York, 1894, pp. 759, 760.

Caladium, this stem-like character is less evident. The potato is an excellent example of the short and much-thickened underground stem known as a *tuber*.

It may be seen from Fig. 33 that the potatoes are none of them borne on true roots, but only on subterranean branches, which are stouter and more cylindrical than most of the roots. The "eyes" which they bear are rudimentary leaves and buds.

FIG. 32. Roots, Rootstocks, and Leaves of Iris.

Bulbs, whether coated like those of the onion or the hyacinth (Fig. 34), or scaly like those of the lily, are merely very short and stout underground stems, covered with closely crowded scales or layers which represent leaves or the bases of leaves (Fig. 35).

The variously modified forms of underground stems just discussed illustrate in a marked way the storage of nourishment during the winter (or the rainless season, as the case may be) to secure rapid growth during the active season. It is interesting to notice that nearly all of the early flowering herbs in temperate climates, like the crocus, the snowdrop, the spring-beauty, the tulip, and

FIG. 33. Part of a Potato Plant.

The dark tuber in the middle is the one from which the plant has grown.

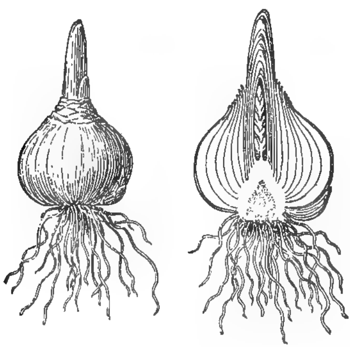


FIG. 34. Bulb of Hyacinth.

Exterior view and split lengthwise.

the skunk-cabbage, owe their early-blooming habit to richly stored underground stems of some kind, or to thick, fleshy roots.

77. Condensed Stems. — The plants of desert regions require, above all, protection from the extreme dryness of the surrounding air, and, usually, from the excessive heat of the sun. Accordingly many desert plants are found quite destitute of ordinary foliage, exposing to the air only a small surface. In the melon-cactuses (Fig. 81) the stem appears reduced to the shape in which the least possible surface is presented by a plant of given bulk, — that is, in a globular form. Other cactuses are more or less cylindrical or prismatic, while still others consist of flattened joints; but all agree in offering much less area to the sun and air than is exposed by an ordinary leafy plant.

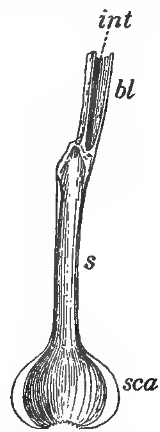


FIG. 35. Longitudinal Section of an Onion Leaf.

sca, thickened base of leaf, forming a bulb-scale; *s*, thin sheath of leaf; *bl*, blade of leaf; *int*, hollow interior of blade.

78. Leaf-like Stems. — The flattened stems of some kinds of cactus (especially the common, showy *Phyllocactus*) are sufficiently like fleshy leaves, with their dark green color and imitation of a midrib, to pass for leaves. There are, however, a good many cases in which the stem takes on a more strikingly leaf-like form. The common asparagus sends up in spring shoots that bear large scales which are really reduced leaves. Later in the season, what seem like thread-like leaves cover the much-branched mature plant, but these green threads are actually minute branches, which perform the work of leaves (Fig. 36). The familiar greenhouse climber, wrongly known as smilax (properly called *Myrsiphyllum*), bears a profusion of what appear to be delicate green leaves (Fig. 37). Close study, however, shows that these are really short, flattened branches, and that each little branch springs from the

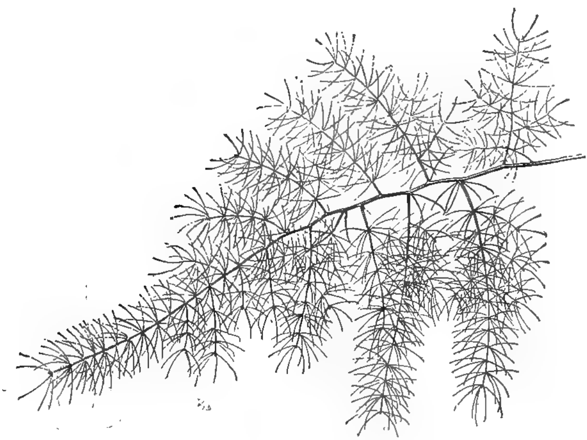


FIG. 36. A Spray of a Common Asparagus (not the edible species).

axil of a true leaf, *l*, in the form of a minute scale. Sometimes a flower and a leaf-like branch spring from the axil of the same scale.

Branches which, like those of *Myrsiphyllum*, so closely resemble leaves as to be almost indistinguishable from them are called *cladophylls*.

79. Modifiability of the Stem. — The stem may, as in the tallest trees in the great lianas of South American forests or the rattan of Indian jungles, reach a length of many hundred feet. On the other hand, in such "stemless" plants as the primrose and the dandelion, the stem may be reduced to a fraction of an inch in length. It may take on apparently root-like forms, as in many grasses and sedges, or become thickened by underground deposits of starch and other plant-food, as in the iris, the potato, and

FIG. 37. Stem of "Smilax" (*Myrsiphyllum*).

l, scale-like leaves; *cl*, cladophyll, or leaf-like branch, growing in the axil of the leaf; *ped*, flower-stalk, growing in the axil of a leaf.

the crocus. Condensed forms of stem may exist above ground, or, on the other hand, branches may be flat and thin enough to imitate leaves closely. In short, the stem manifests great readiness in adapting itself to the most varied conditions of existence.

80. Review Summary of Stems.[1]

Kinds of branching due to leaf arrangement	1. 2.
Kinds of tree-trunk due to greater or less predominance of terminal bud	1. 2.
Classes of plants based on amount of woody stem . .	1. 2. 3.
Classes of plants based on duration of life	1. 2. 3.
Various modes of climbing	1. 2. 3.
Kinds of underground stem	1. 2. 3.
Condensed stems above ground	
Leaf-like stems	

[1] Where it is possible to do so, make sketches; where this is not possible, give examples of plants to illustrate the various kinds or classes of plants in the summary.

CHAPTER VII

STRUCTURE OF THE STEM

STEM OF MONOCOTYLEDONOUS PLANTS

81. Gross Structure. — Refer back to the sketches of the corn-seedling to recall something of the early history of the corn-stem. Study the external appearance of a piece of corn-stem or bamboo two feet or more in length. Note the character of the outer surface. Sketch the whole piece and label the enlarged *nodes* and the nearly cylindrical *internodes*. Cut across a corn-stem and examine the cut surface with the magnifying glass. Make some sections as thin as they can be cut and examine with the magnifying glass (holding them up to the light) or with a dissecting microscope. Note the firm rind composed of the epidermis and underlying tissue, the large mass of pith composing the main bulk of the stem, and the many little harder and more opaque spots, which are the cut-off ends of the woody threads known as *fibro-vascular bundles* (Fig. 38, *cv*).

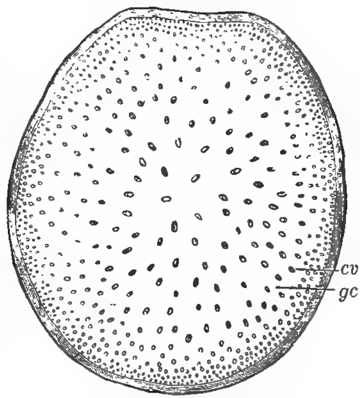


FIG. 38. Diagrammatic Cross-Section of Stem of Indian Corn.

cv, fibro-vascular bundles; *gc*, pithy material between bundles.

Split a portion of the stem lengthwise into thin translucent slices and notice whether the bundles seem to run straight up and down its length; sketch the entire section × 2. Every fibro-vascular bundle of the stem passes outward through some node in order to connect with some fibro-vascular bundle of a leaf. This fact being known to the student would lead him to expect to find the bundles bending out of a vertical position more at the nodes than elsewhere. Can this be seen in the stem examined?

Observe the enlargement and thickening at the nodes, and split one of these lengthwise to show the tissue within it.

Compare with the corn-stem a piece of palmetto and a piece of cat-brier (*Smilax rotundifolia*, *S. hispida*, etc.), and notice the similarity of structure, except for the fact that the tissue in the palmetto and the cat-brier, which answers to the pith of the corn-stem, is much darker colored and harder than corn-stem pith. Compare also a piece of rattan and of bamboo.

82. Minute Structure. — Cut a thin cross-section of the corn-stem, examine with a low power of the microscope, and note:

(*a*) The rind (not true bark), composed largely of hard, thick-walled dead cells known as *sclerenchyma* fibers.

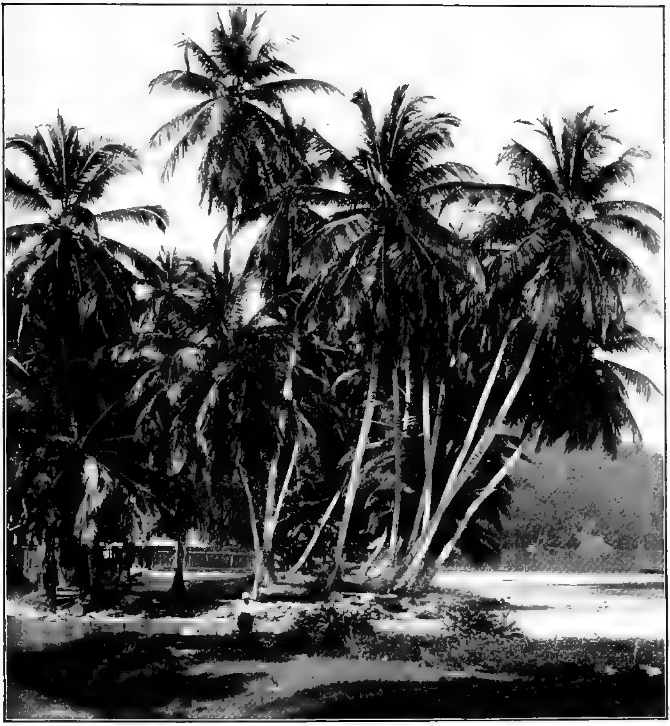
(*b*) The fibro-vascular bundles. Where are they most abundant? least abundant?

(*c*) The pith, occupying the intervals between the fibro-vascular bundles.

Study the bundles in various portions of the section and notice particularly whether some are more porous than others. Explain. Sketch some of the outer and some of the inner ones.

A more complicated kind of monocotyledonous stem-structure can be studied to advantage in the surgeons' splints cut from yucca-stems and sold by dealers in surgical supplies.

83. Mechanical Function of the Manner of Distribution of Material in Monocotyledonous Stems. — The well-known strength and lightness of the straw of our smaller grains and of rods of cane or bamboo are due to their form. It can readily be shown by experiment that an iron or steel tube of moderate thickness, like a piece of gas-pipe or of bicycle-tubing, is much stiffer than a solid rod of



Photograph furnished by the United Fruit Co.

Plate II. Cocoa Palms.

the same weight per foot. The oat straw, the stems of bulrushes, the cane (of our southern canebrakes), and the bamboo are hollow cylinders; the cornstalk is a solid cylinder, but filled with a very light pith. The flinty outer layer of the stalk, together with the closely packed sclerenchyma fibers of the outer rind and the frequent fibro-vascular bundles just within this, are arranged in the best way to secure stiffness. In a general way, then, we may say that the pith, the bundles, and the sclerenchymatous rind are what they are and where they are to serve important mechanical purposes. But they have other uses fully as important.

84. Growth of Monocotyledonous Stems in Thickness. — In most woody monocotyledonous stems, for a reason which will be explained later in this chapter, the increase in thickness is strictly limited. Such stems, therefore, as in many palms and in rattans, are less conical and more cylindrical than the trunks of ordinary trees and are also more slender in proportion to their height (Plate II).

STEM OF DICOTYLEDONOUS PLANTS

85. Gross Structure of an Annual Dicotyledonous Stem. — Study the external appearance of a piece of sunflower-stem several inches long. If it shows distinct nodes, sketch it. Examine the cross-section and sketch it as seen with the magnifying glass or the dissecting microscope. *After your sketch is finished*, compare it with Fig. 39, which probably shows more details than your drawing, and label the parts shown as they are labeled in that figure. Split a short piece of the stem lengthwise through the center and study the split surface with the magnifying glass. Take a sharp knife or a scalpel and carefully slice and then scrape away the bark until you come to the outer surface of a bundle.

Examine a vegetable sponge (*Luffa*), sold by druggists, and notice that it is simply a network of fibro-vascular bundles. It is the skeleton of a tropical seed-vessel or fruit, very much like that of the wild cucumber common in the Central States, but a great deal larger.

The different layers of the bark cannot all be well recognized in the examination of a single kind of stem. Examine (*a*) the *cork*

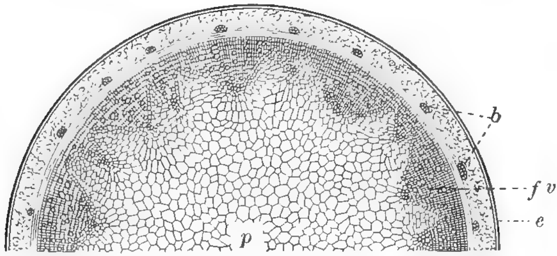


Fig. 39. Diagrammatic Cross-Section of an Annual Dicotyledonous Stem. (Somewhat magnified.)

p, pith; *fv*, woody or fibro-vascular bundles; *e*, epidermis; *b*, bundles of hard bast fibers of the bark.

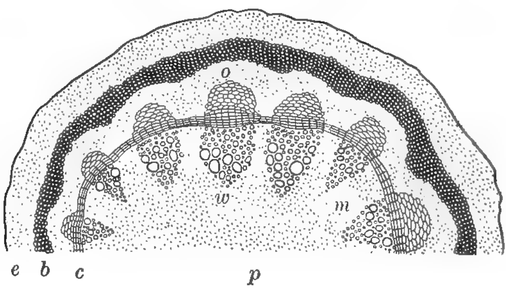


Fig. 40. Diagrammatic Cross-Section of One-Year-Old *Aristolochia* Stem. (Considerably magnified.)

e, region of epidermis; *b*, hard bast; *o*, outer or bark part of a bundle (the cellular portion under the letter); *w*, inner or woody part of bundle; *c*, cambium layer; *p*, region of pith; *m*, a medullary ray.
The space between the hard bast and the bundles is occupied by thin-walled, somewhat cubical cells of the bark.

which constitutes the outer layers of the bark of cherry or birch branches two or more years old. Sketch the roundish or oval spongy *lenticels* on the outer surface of the bark. How far in do they extend? Examine (*b*) the *green layer* of bark as shown in twigs or

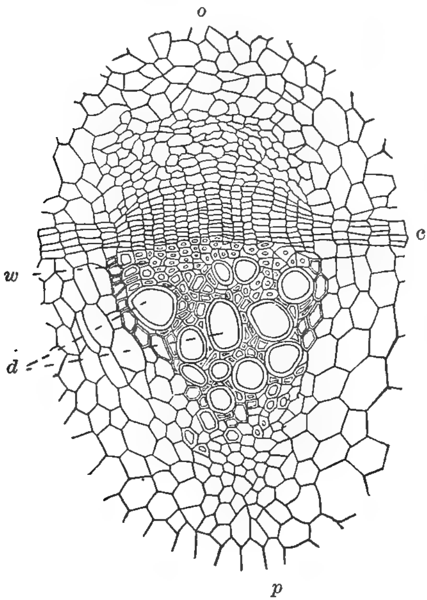


FIG. 41. One Bundle from the Preceding Figure. (× 100.)

w, wood-cells; *d*, ducts. The other letters are as in Fig. 40. Many sieve-cells occur in the region just outside of the cambium of the bundle.

branches of Forsythia, cherry, alder, box-elder, wahoo, or willow. Examine (*c*) the white, fibrous inner layer, known as *hard bast*, of the bark of elm, leatherwood, pawpaw, or basswood.

86. Minute Structure of the Dicotyledonous Stem. — Study, first with a low and then with a medium power of the compound microscope, thin cross-sections of clematis-stem cut just before the end of the first season's growth.[1] Sketch the whole section without much detail, and then make a detailed drawing of a sector running from center to circumference and just wide enough to include one of the large bundles. Label these drawings in general like Figs. 40, 41.

Note: (*a*) The general outline of the section.
(*b*) The number and arrangement of the bundles. (How many kinds of bundles are there?)
(*c*) The comparative areas occupied by the woody part of the bundle and by the part which belongs to the bark.
(*d*) The way in which the pith and the outer bark are connected (and the bundles separated) by the *medullary rays*.

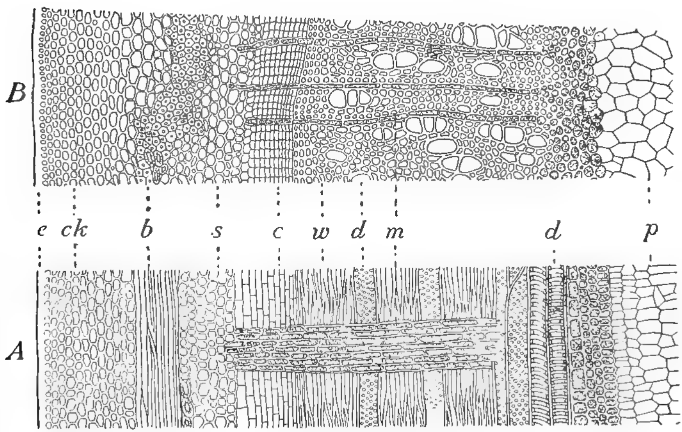


FIG. 42. Stem of Box-Elder One Year Old. (Much magnified.)

A, lengthwise (radial) section; *B*, cross-section. *e*, epidermis; *ck*, cork; *b*, hard bast; *s*, sieve-cells; *c*, cambium; *w*, wood-cells; *m*, medullary rays; *d*, ducts; *p*, pith.

Examine a longitudinal section of the same kind of stem to find out more accurately of what kinds of cells the pith, the bundles, and the outer bark are built. Which portion has cells that are nearly equal in shape, as seen in both sections?

[1] *Clematis virginiana* is simpler in structure than some of the other woody species. *Aristolochia* sections will do very well.

87. The Early History of the Stem. — In the earliest stages of the growth of the stem it consists entirely of thin-walled and rapidly dividing cells. Soon, however, the various kinds of tissue which are found in the full-grown stem begin to appear.

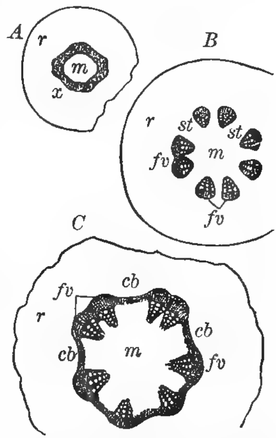


FIG. 43. Transverse Section through the Hypocotyl of the Castor-Oil Plant at Various Stages. (Considerably magnified.)

A, after the root has just appeared outside the testa of the seed; *B*, after the caulicle is nearly an inch long; *C*, at the end of germination; *r*, cortex (undeveloped bark); *m*, pith; *st*, medullary rays; *fv*, fibro-vascular bundles; *cb*, layer of tissue which is to develop into cambium.

In Fig. 43 the process is shown as it occurs in the castor bean. At *m*, in *B*, is the central column of pith surrounded by eight fibro-vascular bundles, *fv*, each of which contains a number of ducts arranged in a pretty regular manner and surrounded by the forerunners of the true wood-cells.

In *C* the section shows a considerable advance in growth: the fibro-vascular bundles are larger and are now connected by a rapidly growing layer of tissue, *cb*.

As growth continues this layer becomes the *cambium layer*, composed of thin-walled and rapidly dividing cells, as shown in Fig. 45.

88. Secondary Growth. — From the inside of the cambium layer the wood-cells and ducts of the mature stem are produced, while from its outer circumference the new layers of the bark proceed. From this mode of increase the stems of dicotyledonous plants are called *exogenous*, that is, outside-growing. The presence of the cambium layer on the outside of the wood in early spring is a fact well known to the schoolboy who pounds the cylinder cut from an alder, willow, or hickory branch until the bark will slip off and so enable him to make a whistle. The sweet taste of this pulpy layer, as found in the white pine, the slippery elm, and the basswood, is a familiar evidence of the nourishment which the cambium layer contains.

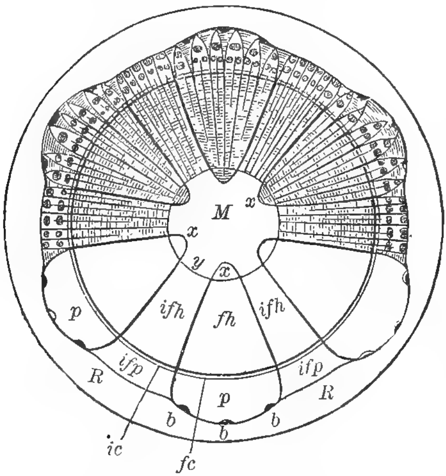


Fig. 44. Diagram to illustrate Secondary Growth in a Dicotyledonous Stem.

R, the first-formed bark; *p*, mass of sieve-cells; *ifp*, mass of sieve-cells between the original wedges of wood; *fc*, cambium of wedges of wood; *ic*, cambium between wedges; *b*, groups of bast-cells; *fh*, wood of the original wedges; *ifh*, wood formed between wedges; *x*, earliest wood formed; *M*, pith.

With the increase of the fibro-vascular bundles of the wood the space between them, which appears relatively large in Fig. 40, becomes less and less, and the pith, which at first extended freely out toward the circumference of the stem, becomes compressed into thin plates so as to form medullary rays. These are, as already stated, of use in storing the food which the plant in cold and temperate climates lays up in the summer and fall for use in the following spring, and in the very young stem they serve as an important channel for the transference of fluids across the stem from bark to pith, or in the reverse direction. On account, perhaps, of their importance to the plants, the cells of the medullary rays are among the longest lived of all vegetable cells, retaining their vitality in the beech tree sometimes, it is said, for more than a hundred years.

After the interspaces between the first fibro-vascular bundles have become filled up with wood, the subsequent growth must take place in the manner shown in Fig. 44. The cambium of the original wedges of wood, *fc*, and the cambium, *ic*, formed between these wedges, continues to grow from its inner and from its outer surface, and thus causes a permanent increase in the diameter of the stem and a thickening of the bark, which, however, usually soon begins to peel off from the outside and thus soon attains a pretty constant thickness.

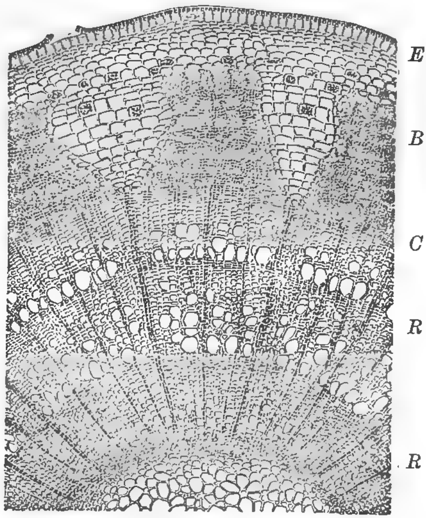


FIG. 45. Cross-Section of a Three-Year-Old Linden Twig. (Much magnified.)

E, epidermis and corky layer of the bark; *B*, bast; *C*, cambium layer; *R*, annual rings of wood.

89. The Dicotyledonous Stem, thickened by Secondary Growth. — Cut off, as smoothly as possible, a small branch of hickory and one of white oak above and below each of the rings of scars already mentioned (Sect. 63), and count the rings of wood above and below each ring of scars.

How do the numbers correspond? What does this indicate?

Count the rings of wood on the cut-off ends of large billets of some of the following woods: locust, chestnut, sycamore, oak, hickory.

Do the successive rings of the same tree agree in thickness?

Why? or why not?

Does the thickness of the rings appear uniform all the way round the stick of wood? If not, the reason in the case of an upright stem (trunk) is perhaps that there was a greater spread of leaves on the side where the rings are thickest or because there was unequal pressure caused by bending before the wind.

Do the rings of any one kind of tree agree in thickness with those of all the other kinds? What does this show?

In all the woods examined look for:

(*a*) Contrasts in color between the heartwood and the sapwood.[1]

(*b*) The narrow lines running, in very young stems, pretty straight from pith to bark, in older wood extending only a little of the way from center to bark, the *medullary rays* shown in Fig. 42.[2]

(*c*) The wedge-shaped masses of wood between these.

(*d*) The pores which are so grouped as to mark the divisions between successive rings. These pores indicate the cross-sections of *vessels* or *ducts*. Note the distribution of the vessels in the rings to which they belong; compare this with Fig. 45 and decide at what season of the year the largest ducts are mainly produced. Make a careful drawing of the end-section of one billet of wood, natural size.

Cut off a grapevine several years old and notice the great size of the vessels. Examine the smoothly planed surface of a billet of red oak that has been split through the middle of the tree, and note the large shining plates formed by the medullary rays.

Look at another stick that has been planed away from the outside until a good-sized flat surface is shown, and see how the medullary rays are here represented only by their edges.

[1] This is admirably shown in red cedar, black walnut, barberry, black locust, and osage orange.

[2] These and many other important things are admirably shown in the thin wood-sections furnished for $5 per set of 24 by R. B. Hough, Lowville, N.Y.

90. Grafting. — When the cambium layer of any vigorously growing stem is brought in contact with this layer in another stem of the same kind or a closely similar kind of plant, the two may grow together to form a single stem or branch. This process is called *grafting*, and is much resorted to in order to secure apples, pears, etc., of any desired kind (Fig. 46). A twig known as the *scion* from a tree of the chosen variety is grafted on to any kind of tree *of the same species* known as the *stock*, and the resulting stems will bear the wished-for kind of fruit. Often one species is grafted on another, as the pear on the quince or the apple. Rarely trees differing as much as the chestnut and the oak may be grafted together. Sometimes grafting comes about naturally by the branches of a tree chafing against one another until the bark is worn away and the cambium layer of each is in contact with that of the other, or two separate trees may be joined by natural grafting.

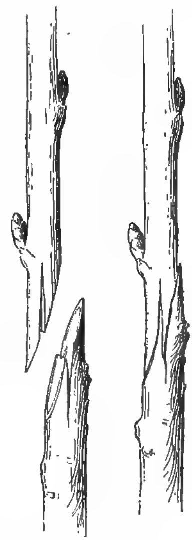


FIG. 46. Grafting.
At the left scion and stock are shown ready to be united; at the right they are joined and ready to cover with grafting wax.

CHAPTER VIII

LIVING PARTS OF THE STEM; WORK OF THE STEM

91. Active Portions of the Stems of Trees and Shrubs. — In annual plants generally and in the very young shoots of shrubs and trees there are *stomata* or breathing pores which occur abundantly in the epidermis, serving for the admission of air and the escape of moisture, while the green layer of the bark answers the same purpose that is served by the green pulp of the leaf (Chapter XIII). For years, too, the spongy lenticels, which succeed the stomata and occur scattered over the external surface of the bark of trees and shrubs, serve to admit air to the interior of the stem. The lenticels at first appear as roundish spots of very small size, but as the twig or shoot on which they occur increases in diameter the lenticel becomes spread out at right angles to the length of the stem, so that it sometimes becomes a longer transverse slit or scar on the bark, as in the cherry and the birch. But in the trunk of a large tree no part of the bark except the inner layer is alive. The older portions of the bark, such as the highly developed cork of the cork-oak, from which the ordinary stoppers for bottles are made, sometimes cling for years after they are dead and useless except as a protection for the parts beneath against mechanical injuries or against cold. But in many cases, as in the shell-bark hickory and the grapevine, the old bark soon falls off in strips. The cambium layer is very much alive, and so is the young outer portion of the wood. Testing this sapwood, particularly in winter, when it serves for food storage, shows that it is rich in starch and proteids.

The heartwood of a full-grown tree is hardly living unless the cells of the medullary rays retain their vitality; and so wood of this kind is useful to the tree mainly by giving stiffness to the trunk and larger branches, thus preventing them from being easily broken by storms.

It is, therefore, possible for a tree to flourish, sometimes for centuries, after the heartwood has much of it rotted away and left the interior of the trunk hollow. This is well shown in the trunk of many old elms, sycamores, and other trees. In the Sequoias, or big trees of California, there are sometimes cavities large enough to allow a two-horse covered wagon to drive inside; and the "chestnut of a hundred horses" on Mt. Etna gets its name from the fact that the interior cavity would easily hold that number of horsemen. In this case, however, there is some doubt whether the whole was originally a single trunk.

92. Uses of the Components of the Stem. — There is a marked division of labor among the various groups of cells that make up the stem of ordinary dicotyledons, particularly in the stems of trees, and it will be best to explain the uses of the kinds of cells as found in trees rather than in herbaceous plants. A few of the ascertained uses of the various tissues are these:

The pith forms a large portion of the bulk of very young shoots, since it is a part of the tissue of comparatively simple structure amid which the fibro-vascular bundles arise. In mature stems it becomes unimportant, though it often long continues to act as a storehouse of food.

The medullary rays in the young shoot serve as a channel for the transference of water and plant-food in a liquid form across the stem, and they often contain much stored food.

The vessels carry water upward and (sometimes) air downward through the stem.

The wood-cells of the heartwood are useful only to give stiffness to the stem. Those of the sapwood, in addition to this work, have to carry most of the water from the roots to the leaves and other distant portions of the plant.

The cambium layer is the region in which the annual growth of the tree takes place.

The most important portion of the inner bark is that which consists of sieve-tubes, for in these digested and elaborated plant-food is carried from the leaves toward the roots.

The green layer of the bark in young shoots does much toward collecting nutrient substances, or raw materials, and preparing the food of the plant from air and water, but this work may be best explained in connection with the study of the leaf (Chapter XIII).

93. Movement of Water in the Stem. — The student has already learned that large quantities of water are taken up by the roots of plants.

Having become somewhat acquainted with the structure of the stem, he is now in a position to investigate the question as to how the various fluids, commonly known as sap, travel about in it.[1] It is important to notice that sap is by no means the same substance everywhere and at all times. As it first makes its way by osmotic action inward

[1] See the paper on *The So-called Sap of Trees and its Movements*, by Professor Charles R. Barnes, *Science*, Vol. XXI, p. 535.

through the root-hairs of the growing plant it differs but little from ordinary spring water or well water. The liquid which flows from the cut stem of a "bleeding" grapevine, which has been pruned just before the buds have begun to burst in the spring, is mainly water with dissolved organic acids, proteids, and sugar. The sap which is obtained from maple trees in late winter or early spring, and is boiled down for syrup or sugar, is still richer in nutritious material than the water of the grapevine, while the elaborated sap which is sent so abundantly into the ear of corn at its period of filling out, or into the growing pods of beans and peas, or into the rapidly forming acorn or the chestnut, contains great stores of food suited to sustain plant or animal life.

EXPERIMENT XI

Rise of Water in Stems. — Cut some short branches from an apple tree or a cherry tree and stand the lower end of each in red ink; try the same experiment with twigs of oak, ash, or other porous wood, and after some hours [1] examine with a magnifying glass and with the microscope, using the 2-inch objective, successive cross-sections of one or more twigs of each kind. Note exactly the portions through which the ink has traveled. Pull off the leaves from one of the stems after standing in the eosin solution, and notice the spots on the leaf-scar through which the eosin has traveled. These spots show the positions of the *leaf-traces*, or fibro-vascular bundles, connecting the stem and the leaf. Repeat with several potatoes cut crosswise through the middle. Try also some monocotyledonous stems, such as those of the lily or asparagus. For the sake of comparison between roots and stems, treat any convenient root, such as a parsnip, in the same way.

[1] If the twigs are leafy and the room is warm, only from 5 to 30 minutes may be necessary.

Examine longitudinal sections of some of the twigs, the potatoes, and the roots. In drawing conclusions about the channels through which the ink has risen (those through which the newly absorbed soil-water most readily travels), bear in mind the fact that a slow soakage of the red ink will take place in all directions, and therefore pay attention only to the strongly colored spots or lines.

What conclusions can be drawn from this experiment as to the course followed by the sap?

From the familiar facts that ordinary forest trees apparently flourish as well after the almost complete decay and removal of their heartwood, and that many kinds will live and grow for a considerable time after a ring of bark extending all round the trunk has been removed, it may readily be inferred that the crude sap in trees must rise through some portion of the newer layers of the wood. A tree girdled by the removal of a ring of sapwood promptly dies.

94. Downward Movement of Liquids. — Most dicotyledonous stems, when stripped of a ring of bark and then stood in water, as shown in Fig. 47, and covered with a bell-jar, develop roots only at or near the upper edge of the stripped portion,[1] and this would seem to prove that such stems send their building material — the elaborated sap — largely at any rate down through the bark. Its course is undoubtedly for the most part through the sieve-cells (Fig. 42), which are admirably adapted to convey liquids. In addition to these general upward and downward movements of sap there must be local transfers laterally through the stem, and these are at times of much importance to the plant.

[1] This may be made the subject of a protracted class-room experiment. Strong shoots of willow should be used for the purpose.

Since the liquid building material travels straight down the stem, that side of the stem on which the manufacture of such material is going on most rapidly should grow fastest.

95. Causes of Movements of Water in the Stem. — Some of the phenomena of osmosis were explained in Sect. 60, and the work of the root-hairs was described as due to osmotic action.

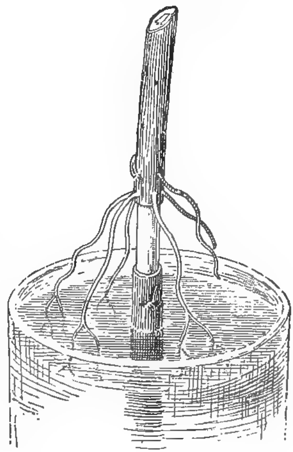


Fig. 47. A Cutting girdled and sending down Roots from the Upper Edge of the Girdled Ring.

Root-pressure (Sect. 61), being apparently able to sustain a column of water only eighty or ninety feet high at the most, and usually less than half this amount, would be quite insufficient to raise the sap to the tops of the tallest trees; some other force or forces must step in to carry it the rest of the way. What these other forces are is still a matter of discussion among botanists.

The slower inward and downward movement of the sap may be explained as due to osmosis. For instance, in the case of growing wood-cells, sugary sap descending from the leaves into the stem gives up part of its sugar to form the cellulose of which the wood-cells are being made.

This loss of sugar would leave the sap rather more watery than usual, and osmosis would carry it from the growing wood to the leaves, while at the same time a slow transfer of the dissolved sugar will be set up from leaves to wood. The water will be thrown off in the form of vapor as fast as it reaches the leaves, so that they will not become distended, while the sugar will be changed into cellulose and built into new wood-cells as fast as it reaches the region where such cells are being formed.

Plants in general[1] readily change starch to sugar, and sugar to starch. When they are depositing starch in any part of the root or stem for future use, the withdrawal of sugar from those portions of the sap which contain it most abundantly gives rise to a slow movement of dissolved particles of sugar in the direction of the region where starch is being laid up.

96. Storage of Food in the Stem. — The reason why the plant may profit by laying up a food supply somewhere inside its tissues has already been suggested (Sect. 76).

The most remarkable instance of storage of food in the stem is probably that of sago-palms, which contain an enormous amount, sometimes as much as 800 pounds, of starchy material in a single trunk. But the commoner plants of temperate regions furnish plenty of examples of deposits of food in the stem. As in the case of seeds and roots, starch constitutes one of the most important kinds of this reserve material of the stem, and since it is easier to detect than any other food material which the plant stores, the student will do well to spend time in looking for starch only.

Cut thin cross-sections of twigs of some common deciduous tree or shrub, in its early winter condition, moisten with iodine solution, and examine for starch with a moderately high power of the microscope. Sketch the section with a pencil, coloring the starchy portions with blue ink, used with a mapping pen, and describe exactly in what portions the starch is deposited.

97. Storage in Underground Stems. — The branches and trunk of a tree furnish the most convenient place in which

[1] Not including most of the flowerless and very low and simple kinds.

to deposit food during winter to begin the growth of the following spring. But in those plants which die down to the ground at the beginning of winter the storage must be either in the roots, as has been described in Sect. 49, or in underground portions of the stem.

Rootstocks, tubers, and bulbs seem to have been developed by plants to answer as storehouses through the winter (or in some countries through the dry season) for the reserve materials which the plant has accumulated during the growing season. The commonest tuber is the potato, and this fact and the points of interest which it represents make it especially desirable to use for a study of the underground stem in a form most highly specialized for the storage of starch and other valuable products.

98. A Typical Tuber: the Potato. — Sketch the general outline of a potato, showing the attachment to the stem from which it grew.[1]

Note the distribution of the "eyes," — are they opposite or alternate? Examine them closely with the magnifying glass and then with the lowest power of the microscope. What do they appear to be?

If the potato is a stem, it may branch, — look over a lot of potatoes to try to find a branching specimen. If such a one is secured, sketch it.

Note the little scale overhanging the edge of the eye and see if you can ascertain what this scale represents.

Cut the potato across and notice the faint broken line which forms a sort of oval figure some distance inside the skin.

Place the cut surface in eosin solution, allow the potato to stand there for many hours, and then examine, by slicing off pieces parallel to the cut surface, to see how far and into what portions the solution has penetrated. Refer to the notes on the study of the parsnip (Sect. 47) and see how far the behavior of the potato treated with eosin solution agrees with that of the parsnip so treated.

[1] Examination of a lot of potatoes will usually discover specimens with an inch or more of attached stem.

Cut a thin section at right angles to the skin and examine with a high power. Moisten the section with iodine solution and examine again.

If possible, secure a potato which has been sprouting in a warm place for a month or more (the longer the better), and look near the origins of the sprouts for evidences of the loss of material from the tuber.

EXPERIMENT XII

Use of the Corky Layer. — Carefully weigh a potato, then pare another larger one, and cut portions from it until its weight is made approximately equal to that of the first one. Expose both freely to the air for some days and reweigh. What does the result show in regard to the use of the corky layer of the skin?

99. Morphology of the Potato. — It is evident that in the potato we have to do with a very greatly modified form of stem. The corky layer of the bark is well represented, and the loose cellular layer beneath is very greatly developed; wood is almost lacking, being present only in the very narrow ring which was stained by the red ink, but the pith is greatly developed and constitutes the principal bulk of the tuber. All this is readily understood if we consider that the tuber, buried in and supported by the earth, does not need the kinds of tissue which give strength, but only those which are well adapted to store the requisite amount of food.

100. Structure of a Bulb; the Onion. — Examine the external appearance of the onion and observe the thin membranaceous skin which covers it. This skin consists of the broad sheathing bases of the outer leaves which grew on the onion plant during the summer. Remove these and notice the thick scales (also formed from bases of leaves as shown in Fig. 35) which make up the substance of the bulb.

Make a transverse section of the onion at about the middle and sketch the rings of which it is composed. Cut a thin section from the interior of the bulb, examine with a moderate power of the microscope, and note the thin-walled cells of which it is composed.

Split another onion from top to bottom and try to find:

(*a*) The *plate* or broad flattened stem inside at the base (Fig. 34).

(*b*) The central bud.

(*c*) The bulb-scales.

(*d*) In some onions (particularly large, irregular ones) the bulblets or side buds arising in the axes of the scales near the base.

Test the cut surface for starch.

101. Plant-Foods in the Onion. — *Grape sugar* is an important substance among those stored for food by the plant. It received its name from the fact that it was formerly obtained for chemical examination from grapes. Old, dry raisins usually show little masses of whitish material scattered over the skin which are nearly pure grape sugar. Commercially it is now manufactured on an enormous scale from starch by boiling with diluted hydrochloric acid. In the plant it is made from starch by processes as yet imperfectly understood, and another sugar, called *maltose*, is made from starch in the seed during germination.

It may be readily shown by suitable experiments that the onion contains both grape sugar and proteids.

102. Tabular Review of Experiments. — [Continue the table from Sect. 38.]

103. Review Summary of Work of Stem.

Channels for upward movement of water	in young dicotyledonous stems. in dicotyledonous stems several years old. in monocotyledonous stems.
Channels for downward movement of water	in dicotyledonous stems. in monocotyledonous stems.
Channels for transverse movements.	
Storage of plant-food	where stored. kinds stored. uses.

CHAPTER IX

BUDS

104. Structure of Buds.— While studying twigs in their winter condition, as directed in Sects. 63, 64, the student had occasion to notice the presence, position, and arrangement of buds on the branch, but he was not called upon to look into the details of their structure. The most natural time to do this is just before the study of the leaf is begun, since leafy stems spring from buds, and the rudiments of leaves in some form must be found in buds.

105. The Horse-Chestnut Bud. — Examine one of the lateral buds on a twig in its winter or early spring condition.[1]

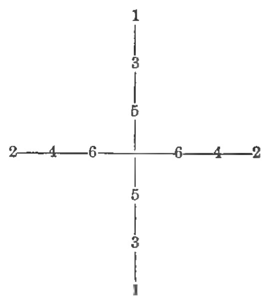
Make a sketch of the external appearance of the buds as seen with a magnifying glass.

How do the scales with which it is covered lie with reference to those beneath them?

Notice the sticky coating on the scales.

Are the scales opposite or alternate?

Remove the scales in pairs, placing them in order on a sheet of paper, thus:



Make the distance from 1 to 1 as much as 6 or 8 inches.

How many pairs are found?

[1] The best possible time for this examination is just as the buds are beginning to swell slightly in the spring. The bud of buckeye or of cottonwood will do for this examination, though each is on a good deal smaller scale than the horse-chestnut bud. Buds may be forced to open early by placing twigs in water in a very warm, light place for many weeks.

Observe as the scales are removed whether the sticky coating is thicker on the outside or the inside of each scale, and whether it is equally abundant on all the successive pairs.

What is the probable use of this coating?

Note the delicate veining of some of the scales as seen through the magnifying glass. What does this mean?

Inside the innermost pair are found two forked woolly objects; what are these?

Compare with Figs. 48 and 55.

Their shape could be more readily observed if the woolly coating were removed.

Can you suggest a use for the woolly coating?

Examine a terminal bud in the same way in which you have just studied the lateral bud.

Does it contain any parts not found in the other?

What is the appearance of these parts?

What do they represent?

If there is any doubt about their nature, study them further on a horse-chestnut tree during and immediately after the process of leafing out in the spring.

FIG. 48. Dissected Bud of Buckeye (*Æsculus macrostachya*), showing Transitions from Bud-Scales to Leaves.

For comparison study at least one of the following kinds of buds in their winter or early spring condition: hickory, butternut, beech, ash, magnolia (or tulip tree), lilac, balm of Gilead, cottonwood, cultivated cherry.[1]

[1] Consult the account of the mode of studying buds in Professor W. F. Ganong's *Teaching Botanist*, pp. 208–210. If some of the buds are studied at home, pupils will have a better chance to examine at leisure the unfolding process.

106. Nature of Bud-Scales. — The fact that the bud-scales are in certain cases merely imperfectly developed leaves or leaf-stalks is often clearly manifest from the series of steps connecting the bud-scale on the one hand with the young leaf on the other, which may be found in many opening buds, as illustrated by Fig. 48. In other buds the scales are not imperfect leaves, but the little appendages (*stipules*, Figs. 63, 64), which occur at the bases of leaves. This kind of bud-scale is especially well shown in the magnolia and the tulip tree.

107. Naked Buds. — All of the buds above mentioned are *winter buds*, capable of living through the colder months of the year, and are scaly buds.

In the herbs of temperate climates, and even in shrubs and trees of tropical regions, the buds are often *naked*, that is, nearly or quite destitute of scaly coverings (Fig. 49).

Make a study of the naked buds of any convenient herb, such as one of the common "geraniums" (*Pelargonium*), and record what you find in it.

108. Position of Buds. — The distinction between *lateral* and *terminal* buds has already been alluded to.

The plumule is the first terminal bud which the plant produces. Lateral buds are usually *axillary*, as shown in Fig. 58, that is, they grow in the angle formed by

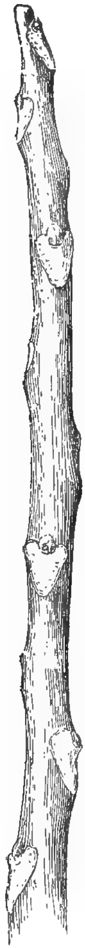


FIG. 49. Tip of Branch of *Ailanthus* in Winter Condition, showing very Large Leaf-Scars and nearly Naked Buds.

the leaf with the stem (Latin *axilla*, armpit). But not infrequently there are several buds grouped in some way about a single leaf-axil, either one above the other, as in the butternut (Fig. 51), or grouped side by side, as in the red maple, the cherry, and the box-elder (Fig. 50).

In these cases all the buds except the axillary one are called *accessory* or *supernumerary* buds.

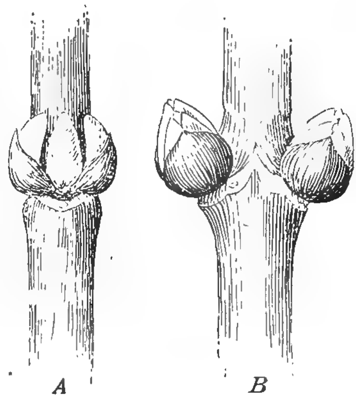


FIG. 50. Accessory Buds of Box-Elder (*Acer Negundo*). (Magnified.)

A, front view of group; *B*, two groups seen in profile.

109. Leaf-Buds and Flower-Buds; the Bud an Undeveloped Branch. — Such buds as the student has so far examined for himself are not large enough to show in the most obvious way the relation of the parts and their real nature.

The cabbage, however, is a gigantic terminal bud which illustrates perfectly the structure of buds in general.

Examine and sketch a rather small, firm cabbage, preferably a red one, which has been split lengthwise through the center and note:

(*a*) The short, thick, conical stem ending in layers of rapidly dividing cells, the *growing apex*, the source of new leaves, and lengthening of the stem.

(*b*) The crowded leaves which arise from the stem, the lower and outer ones largest and most mature, the upper and innermost ones the smallest of the series.

(*c*) The axillary buds found in the angles made by some leaves with the stem.

Most of the buds so far considered were *leaf-buds*, that is, the parts inside of the scales would develop into leaves, and their central axes into stems; but some were *mixed buds*, that is, they contained both leaves and flowers in an undeveloped condition.

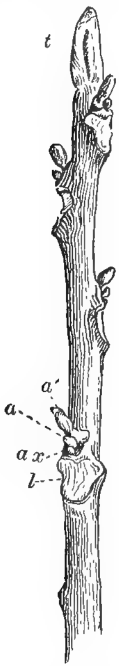


FIG. 51. Accessory Buds of Butternut. (Reduced.)

l, leaf-scar; *ax*, axillary bud; *a*, *a'*, accessory buds; *t*, terminal bud.

Flower-buds contain the rudiments of flowers only.

Sometimes, as in the black walnut and the butternut, the leaf-buds and flower-buds are readily distinguishable by their difference in form, while in other cases, as in the cultivated cherry, the difference in form is but slight.

The rings of scars about the twig, shown in Fig. 54, mark the place where the bases of bud-scales were attached. A little examination of the part of the twig which lies outside of this ring will lead one to the conclusion that this portion has all grown in the one spring and summer since the bud-scales of that particular ring dropped off. Following out this suggestion, it is easy to reckon the age of any moderately old portion of a branch, since it is equal to the number of segments between the rings. In rapidly growing shoots of willow, poplar, and similar trees, 5 or 10 feet of the length may be the growth of a single year, while in the lateral twigs of the hickory, apple, or cherry the yearly increase may be but a fraction of an inch. Such fruiting

FIG. 52.

A, a pear leaf-bud in autumn; *B*, a leafy shoot derived from *A*, as seen in the middle of the following summer, with flower-bud at tip; *C*, the fruit-spur, *B*, in autumn, after the fall of the leaves.

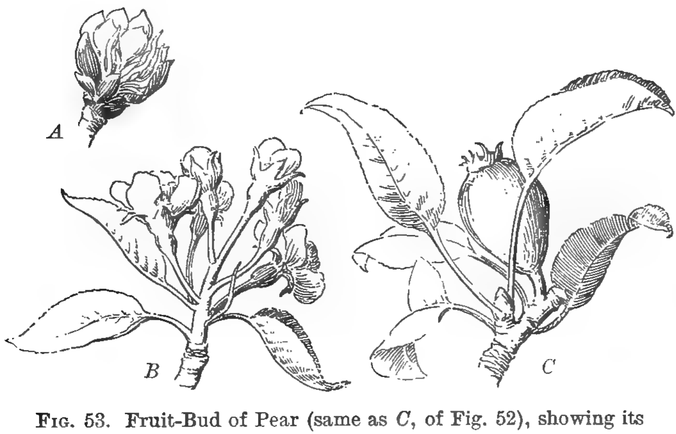


FIG. 53. Fruit-Bud of Pear (same as *C*, of Fig. 52), showing its Development.

A, opening in spring; *B*, later, developing flowers and leaves; *C*, later still: only one flower has produced a fruit, the rest having fallen off. Below it is a lateral bud which will continue the spur next year.

"spurs" as are shown in Fig. 52 are of little use in the permanent growth of the tree, and poplars, elms, soft maples, and other trees shed the oldest of these every year. Whatever the amount of this growth, it is but the lengthening out and development of the bud, which may be regarded as an undeveloped stem or branch, with its internodes so shortened that successive leaves seem almost to spring from the same point. In Figs. 52, 53 the complete history of a fruit-spur of the pear is shown, from the leaf-bud which produced it to the pear which it bears.

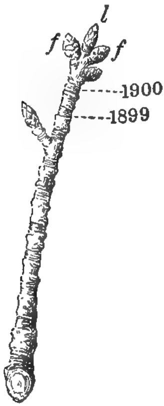


Fig. 54. A Slowly Grown Twig of Cherry, Three Inches Long and about Ten Years Old.

The pointed bud, *l*, is a leaf-bud; the more obtuse accessory buds, *f*, *f*, are flower-buds.

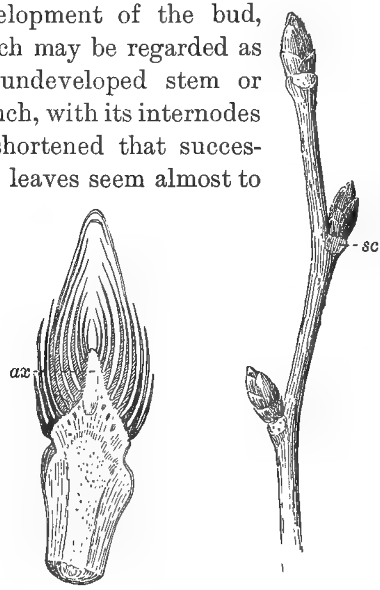


Fig. 55.

B, a twig of European elm; *A*, a longitudinal section of the buds of *B* (considerably magnified). *ax*, the axis of the bud which will elongate into a shoot; *sc*, leaf-scars.

110. Vernation. — Procure a considerable number of buds which are just about to burst and others which have begun to open. Cut each across with a razor or very sharp scalpel; examine first with the magnifying glass and then with the lowest power of the microscope. Pick to pieces other buds of the same kinds under the magnifying glass, and report upon the manner in which the leaves are packed away.

The arrangement of leaves in the bud is called *vernation;* some of the principal modes are shown in Fig. 56.

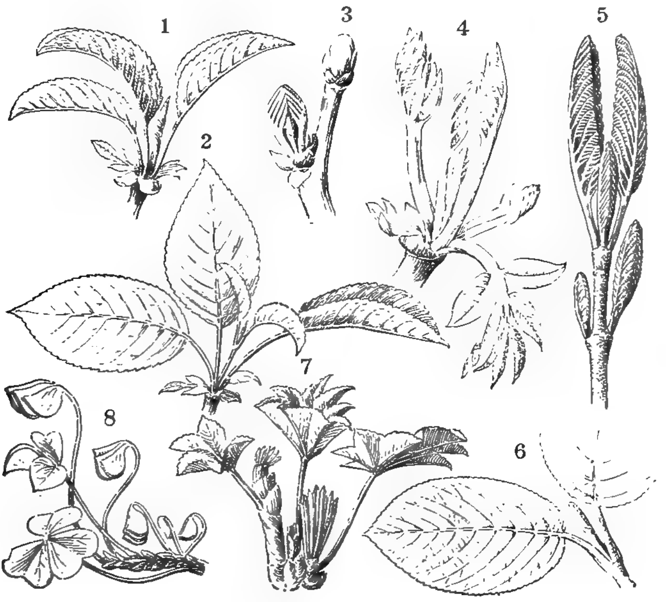


FIG. 56. Types of Vernation.

1, 2, cherry; 3, 4, European walnut; 5, 6, snowball; 7, lady's mantle; 8, oxalis.

In the cherry the two halves of the leaf are folded together flat, with the under surfaces outward; in the walnut the separate *leaflets*, or parts of the leaf, are folded flat and then grouped into a sort of cone; in the snowball each half of the leaf is plaited in a somewhat fan-like manner, and the edges of the two halves are then brought round so as to meet; in the lady's mantle the fan-like plaiting is very distinct; in the wood sorrel each leaflet is folded smoothly, and then the three leaflets are packed closely side by side. All these modes of vernation and many others have received accurate descriptive names by which they are known to botanists.

111. Importance of Vernation. — The significance of vernation is best understood by considering that there are two important purposes to be served: the leaves must be

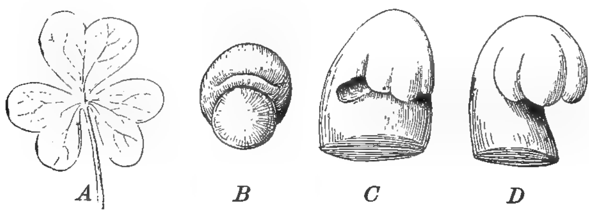


FIG. 57. Development of an Oxalis Leaf.

A, full-grown leaf; *B*, rudimentary leaf, the leaflets not yet evident; *C*, more advanced stage, the leaflets appearing; *D*, a still more advanced stage. (*B*, *C*, and *D* considerably magnified.)

stowed as closely as possible in the bud, and upon beginning to open they must be protected from too great heat and dryness until they have reached a certain degree of firmness. It may be inferred from Fig. 56 that it is common for very young leaves to stand vertically. This protects them considerably from the scorching effect of the sun at the hottest part of the day. Many young leaves, as, for instance, those of the silver-leafed poplar, the pear, the beech, and the mountain ash, are sheltered and protected from the attacks of small insects by a coating of wool or down which they afterwards lose. Those of the tulip tree are enclosed for a little time in thin pouches, which serve as bud-scales, and are thus entirely shielded from direct contact with the outside air.

112. Dormant Buds. — Generally some of the buds on a branch remain undeveloped in the spring, when the other buds are beginning to grow, and this inactive condition may last for many seasons. Finally the bud may die, or some injury to the tree may destroy so many other buds as to leave the dormant ones an extra supply of food, and this, with other causes, may force them to develop and to grow into branches.

Sometimes the tree altogether fails to produce buds at places where they would regularly occur. In the lilac the terminal bud usually fails to appear, and the result is constant forking of the branches.

113. Adventitious Buds. — Buds which occur in irregular places, that is, not terminal nor in or near the axils of leaves, are called *adventitious buds;* they may spring from the roots, as in the silver-leafed poplar, or from the sides of the trunk, as in our American elm. In many trees, for instance willows and maples, they are sure to appear after the trees have been cut back. Willows and poplars are thus cut back or *pollarded*, as shown in Plate III, in order to cause them to produce a large crop of slender twigs suitable for basket-making or for withes.

Leaves rarely produce buds, but a few kinds do so when they are injured. Those of the bryophyllum, a plant allied to the garden live-for-ever, when they are removed from the plant while they are still green and fresh, almost always send out buds from the margin. These do not appear at random but are borne at the notches in the leaf-margin and are accompanied almost from the first by minute roots.

Pin up a bryophyllum leaf on the wall of the room or lay it on the surface of moist earth, and follow day by day the formation and development of the buds which it may produce.

This plant seems to rely largely upon leaf-budding to reproduce itself, for in a moderately cool climate it rarely flowers or seeds, but drops its living leaves freely, and from each such leaf one or several new plants may be produced.

114. Review Summary of Chapter IX.

- Buds
  - Coverings.
  - Contents . . .
    - leaf-buds.
    - flower-buds.
    - mixed buds.
- Classes of buds as regards position . . . . . .
  - regular .
  - irregular.

Make a sketch of Fig. 58 as it looked in June of the same summer; also as it would look the following June (Fig. 58 represents the autumn condition). Sketch the twigs of Fig. 24 and Fig. 25 as seen one year later.

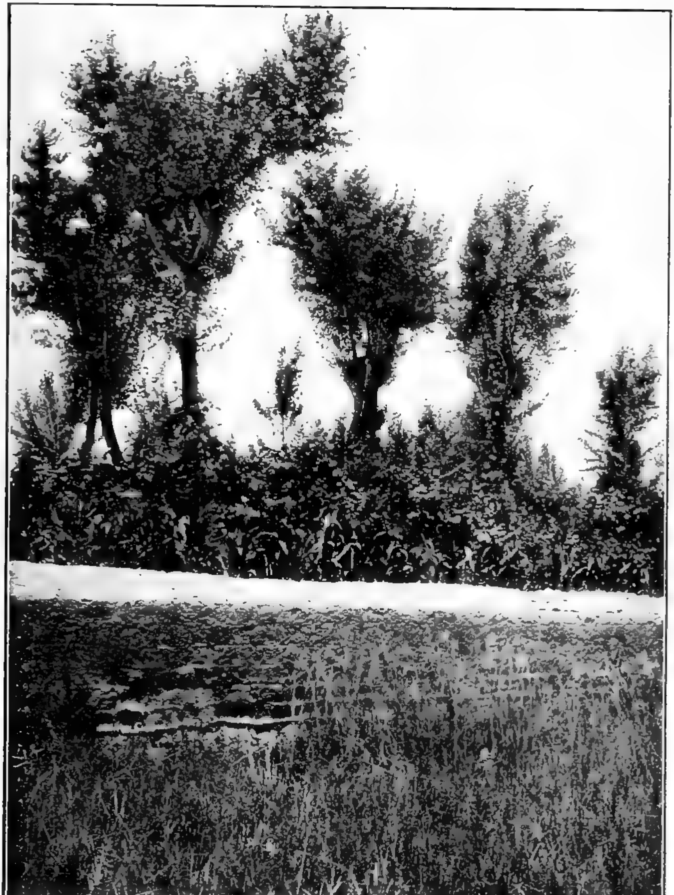


Plate III. Pollarded Poplars.

CHAPTER X

LEAVES

115. The Elm Leaf. — Sketch the leafy twig of elm that is supplied to you.[1] Report on the following points:

(*a*) How many rows of leaves?

(*b*) How much overlapping of leaves when the twig is held with the upper sides of the leaves toward you? Can you suggest a reason for this? Are the spaces between the edges of the leaves large or small compared with the leaves themselves?

Pull off a single leaf and make a very

Fig. 58. Leafy Twig of Poplar

[1] Any elm will answer the purpose. Young strong shoots which extend horizontally are best, since on these leaves are most fully developed and their distribution along the twig appears most clearly. Other good kinds of leaves with which to begin the study, if elm leaves are not available, are those of beech, oak, willow, peach, cherry, apple. Most of the statements and directions above given would apply to any of the leaves just enumerated. If this chapter is reached too early in the season to admit of suitable material being procured for the study of leaf arrangement, that topic may be omitted until the leaves of forest trees have sufficiently matured.

careful sketch of its under surface, about natural size. Label the broad expanded part the *blade*, and the stalk by which it is attached to the twig, *leaf-stalk* or *petiole*.

Study the outline of the leaf and answer these questions:

(*a*) What is the shape of the leaf taken as a whole? (See Appendix.) Is the leaf *bilaterally symmetrical*, *i.e.*, is there a middle line running through it lengthwise, along which it could be so folded that the two sides would precisely coincide?

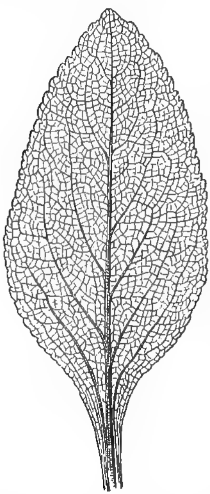


Fig. 59. Netted Veining (pinnate) in Leaf of Foxglove.

(*b*) What is the shape of the tip of the leaf? (See Appendix I.)

(*c*) Shape of the base of the leaf? (See Appendix I.)

(*d*) Outline of the margin of the leaf? (See Appendix I.)

Notice that the leaf is traversed lengthwise by a strong *midrib* and that many so-called *veins* run from this to the margin. Are these veins parallel? Hold the leaf up towards the light and see how the main veins are connected by smaller *veinlets*. Examine with your glass the leaf as held to the light and make a careful sketch of portions of one or two veins and the intersecting veinlets. How is the course of the veins shown on the upper surface of the leaf?

Examine both surfaces of the leaf with the glass and look for hairs distributed on the surfaces. Describe the manner in which the hairs are arranged.

The various forms of leaves are classed and described by botanists with great minuteness,[1] not simply for the study of leaves themselves, but also because in classifying and describing plants the characteristic forms of the leaves of many kinds of plants form a very simple and ready means of distinguishing them from each other and

[1] See Kerner and Oliver's *Natural History of Plants*, Vol. I, pp. 623–637

identifying them. The student is not expected to learn the names of the several shapes of leaves as a whole or of their bases, tips, or margins, except in those cases in which he needs to use and apply them.

Many of the words used to describe the shapes of leaves are equally applicable to the leaf-like parts of flowers.

FIG. 60. Netted Veining (palmate) in Leaf of Melon.

116. The Maple Leaf. — Sketch the leafy twig.

Are the leaves arranged in rows like those of the elm? How are they arranged?

How are the petioles distorted from their natural positions to bring the proper surface of the leaf upward toward the light?

Do the edges of these leaves show larger spaces between them than the elm leaves did, *i.e.*, would a spray of maple intercept the sunlight more or less perfectly than a spray of elm? Pull off a single leaf and sketch its lower surface, about natural size.

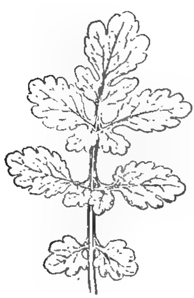


FIG. 61. Pinnately Divided Leaf of Celandine.

The blade of the leaf is discontinuous, consisting of several portions, between which are spaces in which one part of the blade has been developed.

Of the two main parts whose names have already been learned (blade and petiole), which is more developed in the maple than in the elm leaf?

Describe:

(*a*) The shape of the maple leaf as a whole. To settle this, place the leaf on paper, mark the positions of the extreme points, and connect these by a smooth line.

(*b*) Its outline as to main divisions; of what kind and how many?

(*c*) The detailed outline of the margin. (See Appendix I.)

Compare the mode of veining or venation of the elm and the maple leaf by making a diagram of each.

These leaves agree in being *netted-veined*, *i.e.*, in having veinlets that join each other at many angles, so as to form a sort of delicate lace-work, like Figs. 59 and 60.

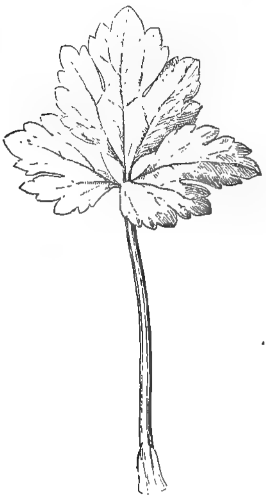


FIG. 62. Palmately Divided Leaf of Buttercup.

They differ, however, in the arrangement of the principal veins. Such a leaf as that of the elm is said to be feather-veined, or *pinnately veined*.

The maple leaf, or any leaf with closely similar venation, is said to be *palmately veined*. Describe the difference between the two plans of venation.

117. Relation of Venation to Shape of Leaves.—As soon as the student begins to observe leaves somewhat widely, he can hardly fail to notice that there is a general relation between the plan of venation and the shape of the leaf. How may this relation be stated? In most cases the principal veins follow at the outset a pretty straight course, a fact for which the student ought to be able to give a reason after he has performed Exp. XVI.

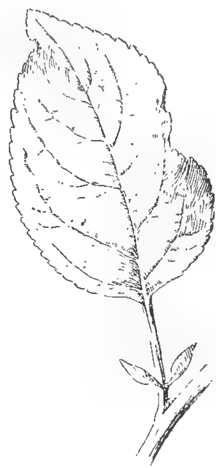


FIG. 63. Leaf of Apple, with Stipules.

On the whole, the arrangement of the veins seems to be such as to stiffen the leaf most in the parts that need most support, and to reach the region near the margin by as short a course as possible from the end of the petiole, to distribute water quickly throughout.

118. Stipules. — Although they are absent from many leaves and disappear early from others, *stipules* often form a part (sometimes the largest and most useful portion) of the leaf.[1] When present they are sometimes found as little bristle-shaped objects at the base of the leaf, as in the apple leaf (Fig. 63), sometimes as leaf-like bodies, for example in the pansy (Fig. 64), and in many other forms, one of which is that of spinous appendages, as shown in the common locust (Fig. 68).

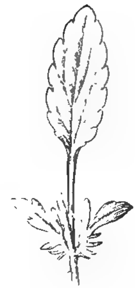


Fig. 64. Leaf of Pansy, with Leaf-like Stipules.

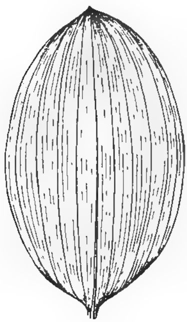


Fig. 65. Parallel-Veined Leaf of Solomon's Seal.

119. Parallel-Veined Leaves. — The leaves of many great groups of plants, such as the lilies, the sedges, and the grasses, are commonly *parallel-veined*, that is, with the veins running nearly parallel, lengthwise through the blade, as shown in Fig. 65, or with parallel

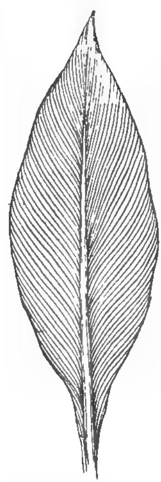


Fig. 66. Parallel Veining in Canna. Veins running from midrib to margin.

[1] Unless the elm twigs used in the previous study were cut soon after the unfolding of the leaves in spring, the stipules may not have been left in any recognizable shape.

veins proceeding from a midrib and thence extending to the margin, as shown in Fig. 66.

120. Occurrence of Netted or Parallel Veining. — The student has already, in his experiments on germination, had an opportunity to observe the difference in mode of veining between the leaves of some dicotyledonous plants and those of monocotyledonous plants. This unlikeness is somewhat general throughout these groups of flowering plants. What is the difference?

Fig. 67. The Fall of the Horse-Chestnut Leaf.

The polycotyledonous pines, spruces, and other coniferous trees have leaves with but a single vein, or two or three parallel ones, but in their case the veining could hardly be other than parallel, since the needle-like leaves are so narrow that no veins of any considerable length could exist except in a position lengthwise of the leaf.

The fact that a certain plan of venation is found mainly in plants with a particular mode of germination, of stem structure, and of arrangement of floral parts, is but one of the frequent cases in botany in which the structures of plants are correlated in a way which is not easy to explain. No one knows why plants with two cotyledons usually have netted-veined leaves, but many such facts as this are familiar to every botanist.

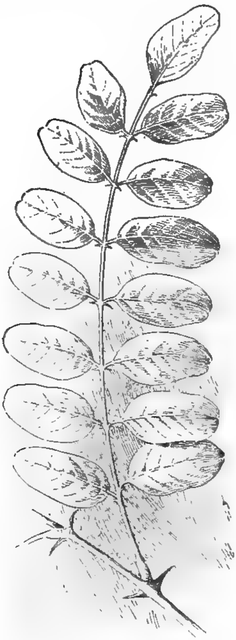


Fig. 68. Pinnately Compound Leaf of Locust, with Spines for Stipules.

121. Simple and Compound Leaves. — The leaves so far studied are *simple leaves*, that is, leaves of which the blades are more or less entirely united into one piece. But while in the elm the margin is cut in only a little way, in some maples it is deeply cut in toward the bases of the veins. In some leaves the gaps between the adjacent portions extend all the way down to the petiole (in palmately veined leaves) or to the midrib (in pinnately veined ones). Such divided leaves are shown in Figs. 61 and 62.

Fig. 69. Pinnately Compound Leaf of Pea. A tendril takes the place of a terminal leaflet.

In still other leaves, known as *compound leaves*, the petiole, as shown in Fig. 67 (*palmately compound*), or the midrib, as shown in Fig. 68 (*pinnately compound*), bears what look to be separate leaves. These differ in their nature and mode of origin from the portions of the blade of a divided leaf. One result of this difference appears in the fact that some time before the whole leaf is ready to fall in autumn, the leaflets of a compound leaf are seen to be jointed at their attachments. In Fig. 67 the horse-chestnut leaf is shown at the time of falling, with some of the leaflets already disjointed.

That a compound leaf, in spite of the joints of the separate leaflets, is really only one leaf is shown: (1) by the absence of buds in the axils of leaflets (see Fig. 68); (2) by the horizontal arrangement of the blades of the leaflets, without any twist in their individual leaf-stalks; (3) by the fact that their arrangement on the midrib does not follow any of the systems of leaf arrangement on the stem (Sect. 124). If each leaflet of a compound leaf should itself become compound, the result would be to produce a *twice compound* leaf. Fig. 77 shows that of an acacia.

122. Review Summary of Leaves.[1]

Parts of a model leaf	1. 2. 3.
Classes of netted-veined leaves	1. 2.
Classes of parallel-veined leaves	1. 2.
Relation of venation to number of cotyledons	
Compound leaves; types dependent on arrangement of leaflets	1. 2.
Once, twice, or three times compound	

[1] Illustrate by sketches if possible.

CHAPTER XI

ECOLOGY OF LEAVES

123. Ecology. — Plant *ecology* includes all that portion of botany which has to do with the way in which plants get on with their animal and plant neighbors, and especially the way in which they adjust themselves to the nature of the soil and climate in which they live. Ecology, in short, discusses the relations of plants to their surroundings or environment. A good deal of what has been said in previous chapters about such topics as variation of roots for life in air or water, parasitic plants, the occurrence of winter bud-scales, is really ecological botany, although it is not so designated in the sections where it occurs.

124. Leaf Arrangement.[1] — As has been learned from the study of the leafy twigs examined, leaves are quite generally arranged so as to secure the best possible exposure to the sun and air. This, in the vertical shoots of the elm, the oak (Fig. 70), the apple, beech, and other alternate-leaved trees, is not inconsistent with their spiral arrangement of the leaves around the stem. In horizontal twigs and branches of the elm, the beech (Fig. 71), the chestnut, the linden, and many other trees and shrubs, the desired effect is secured by the arrangement of all the leaves in two flat rows, one on each side of the twig. The rows are produced, as it is easy to see on examining such a

[1] See Kerner and Oliver's *Natural History of Plants*, Vol. I, pp. 396–424.

leafy twig, by a twisting about of the petioles. The adjustment in many opposite-leaved trees and shrubs consists in having each pair of leaves cover the spaces between the pair below it, and sometimes in the lengthening of the lower petioles so as to bring the blades of the lower leaves outside those of the upper leaves. Examination of Figs. 72 and 73 will make the matter clear.

Fig. 70. Leaf Arrangement of the Oak.

The student should not fail to study the leafage of several trees of different kinds on the growing tree itself, and in climbers on walls, and to notice how circumstances modify the position of the leaves. Maple leaves, for example, on the ends of the branches are arranged much like those of the horse-chestnut, but they are found to be arranged more nearly flatwise along the inner portions of the branches, that is, the portions nearer the tree. Figs. 74 and 75 show the remarkable difference in arrangement in different branches of the Deutzia, and equally interesting modifications may be found in alternate-leaved trees, such as the elm and the cherry.

Fig. 71. Leaf Arrangement of European Beech.

125. Leaf-Mosaics. — In very many cases the leaves at the end of a shoot are so arranged as to form a rather symmetrical pattern, as in the horse-chestnut (Fig. 72). When this is sufficiently regular,

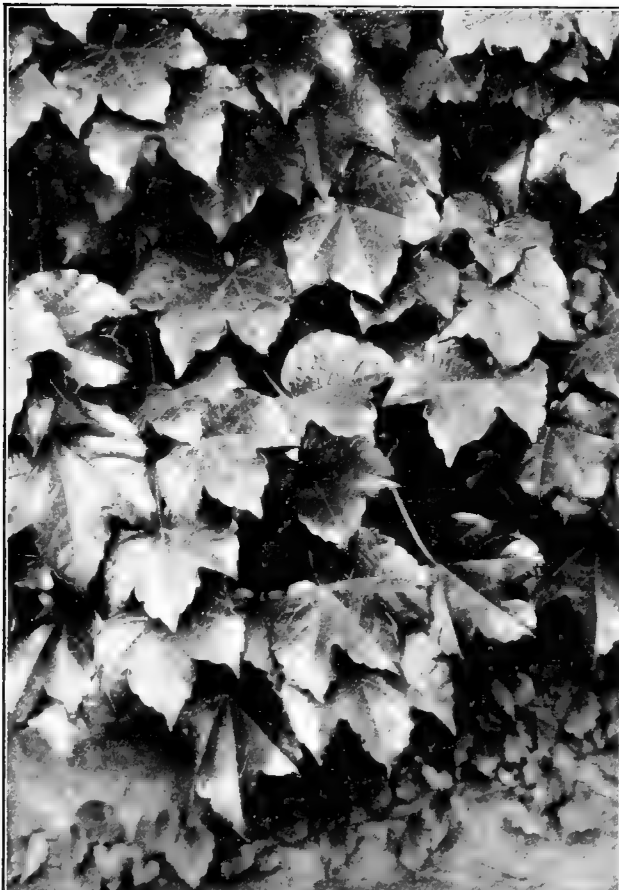


PLATE IV. Leaf Mosaic, Japanese Ivy.

usually with the space between the leaves a good deal smaller than the areas of the leaves themselves, it is called a *leaf-mosaic*. Many of the most interesting leaf-groups of this sort (as in the figure above mentioned) are found in the so-called root-leaves of plants. Good examples of these are the dandelion, chicory, fall dandelion, thistle, hawkweed, pyrola, and plantain. How are the leaves of these plants kept from shading each other?

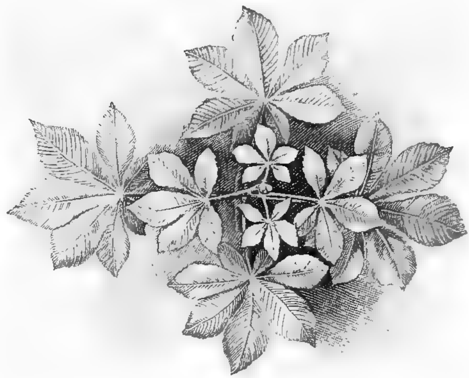


FIG. 72. Leaf Arrangement of Horse-Chestnut on Vertical Shoots (top view).

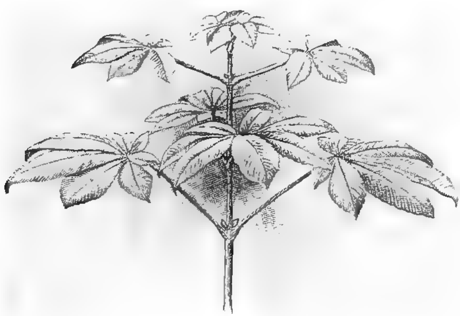


FIG. 73. Leaf Arrangement of Horse-Chestnut on Vertical Shoots (side view).

126. Much-Divided Leaves. — Not infrequently leaves are cut into slender fringe-like divisions, as in the carrot, tansy, southernwood, wormwood, yarrow, dog-fennel, cypress-vine, and many other common plants. This kind of leaf seems to be adapted to offer considerable surface to the sun without cutting off too much light from other leaves underneath. Such a leaf is in much less danger of being torn by severe winds than are broader ones with undivided margins. The same purposes are served by compound leaves with very many small leaflets, such as those of the honey-locust, mimosa acacia (Fig. 77), and

FIG. 74. Opposite Leaves of Deutzia[1] (from the same shrub as Fig. 75), as arranged on a Horizontal Branch.

other trees and shrubs of the pea family. What kind of shade is produced by a horse-chestnut or a maple tree compared with that of a honey-locust or an acacia?

127. Daily Movements of Leaves. — Many compound leaves have the power of changing the position of their leaflets to accommodate themselves to varying conditions of light and temperature. Some plants have the power of directing the leaves or leaflets edgewise towards the sun during the hottest parts of the day, allowing them to

[1] *Deutzia crenata.*

extend their surfaces more nearly in a horizontal direction during the cooler hours.

The so-called "sleep" of plants has long been known, but this subject has been most carefully studied rather recently. The wood sorrel, or oxalis, the common bean, clovers, and the locust tree are some of the most familiar of the plants whose leaves assume decidedly different positions at night from those which they occupy during the day. Sometimes the leaflets rise at night, and in many instances they droop, as in the red clover (Fig. 76) and the acacia (Fig. 77).

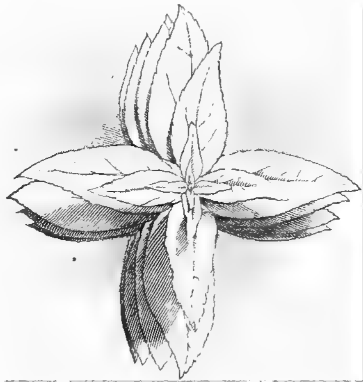


Fig. 75. Opposite Leaves of Deutzia, as arranged on a Vertical Branch.

One useful purpose, at any rate, that is served by the leaf's taking the nocturnal position is protection from frost. It has been proved experimentally that when part of the leaves on a plant are prevented from assuming the folded position, while others are allowed to do so, and the plant is then exposed during a frosty night, the folded ones may escape while the others are killed. Since many plants in tropical climates fold their leaves at night, it is certain

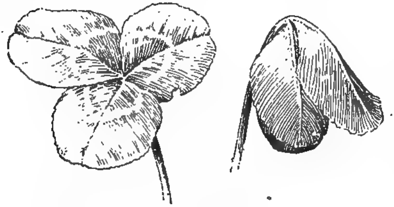


Fig. 76. A Leaf of Red Clover.

At the left, leaf by day; at the right, the same leaf asleep at night.

that this movement has other purposes than protection from frost, and probably there is much yet to be learned about the uses of leaf movements.

128. Vertically Placed Leaves.—Very many leaves, like those of the iris (Fig. 32), always keep their principal surfaces nearly vertical, thus receiving the morning and evening sun upon their faces, and the noonday sun (which is so intense as to injure them when received full on the

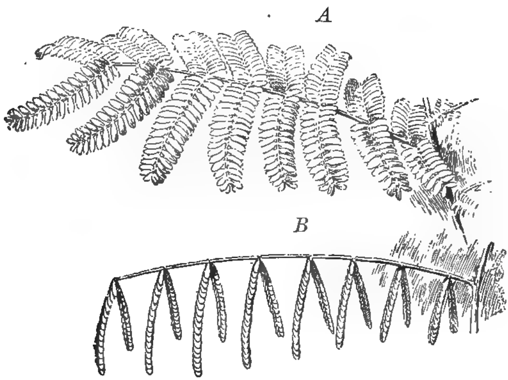


Fig. 77. A Leaf of Acacia.

A, as seen by day; *B*, the same leaf asleep at night.

surface) upon their edges. This adjustment is most perfect in the compass-plant of the prairies of the Mississippi basin. Its leaves stand very nearly upright, many with their edges just about north and south (Fig. 78), so that the rays of the midsummer sun will, during every bright day, strike the leaf-surfaces nearly at right angles during a considerable portion of the forenoon and afternoon, while at midday only the edge of each leaf is exposed to the sun.

FIG. 78. Leaves standing nearly Vertical in Compass-Plant (*Silphium laciniatum*).

A, view from east or west; *B*, from north or south.

129. Movements of Leaves and Stems toward or away from Light (Heliotropic Movements). — The student doubtless learned from his experiments with seedling plants that their stems tend to seek light. The whole plant above ground usually bends toward the quarter from which the strongest light comes. Such movements are called *heliotropic* from two Greek words which mean turning toward the sun. How do the plants in a window behave with reference to the light?

EXPERIMENT XIII

How do Young Shoots of English Ivy bend with Reference to Light? — Place a thrifty potted plant of English ivy before a small window, *e.g.*, an ordinary cellar window, or in a large covered box painted dull black within and open only on the side toward a south window. After some weeks note the position of the tips of the shoots. Explain the use of their movements to the plant.

130. Positive and Negative Heliotropic Movements; how produced. — Plants may bend either toward or away from the strongest light. In the former case they are said to show *positive heliotropism*, in the latter *negative heliotropism.* In both cases the movement is produced by unequal growth brought about by the unequal lighting of different sides of the stem. If the less strongly lighted side grows faster, what kind of heliotropism results? If the more strongly lighted side grows faster, what kind of heliotropism results? How would a plant behave if placed on a revolving table before a window and slowly turned during the hours of daylight?

131. Review Summary of Chapter XI.

Leaf arrangement	for vertical twigs. for horizontal twigs.
Movements of leaves	Uses of.
Compass-plants.	
Heliotropic bending of stems .	positive. negative.

CHAPTER XII

ECOLOGY OF LEAVES (*continued*)

132. Plant Formations.—A little observation is enough to show the beginner in botany that plants are not scattered indiscriminately over the surface of the earth, but that hills, meadows, fresh-water marshes, salt marshes, and many other kinds of localities have their characteristic assemblages of plants. Any such group is called a *plant formation.* It may consist of only a few species, but more commonly comprises several score or even a hundred or more of flowering plants (seed-plants) alone, not to speak of the multitudes of lower forms, such as ferns, mosses, and simpler microscopic plants.

It will generally be found that the members of a plant formation are growing under what is, for them, nearly the best environment, since they cannot usually be made to exchange places with each other. If a square mile of land in Louisiana were to be planted with Minnesota species, and a square mile in Minnesota with Louisiana species, it is very improbable that either tract, if left to itself, would long retain its artificial flora. To this rule there are, however, important exceptions.

133. Ecological Classification of Plants. — The ordinary classification of plants is based, as far as possible, on their actual relationships to each other. But when plants are classified ecologically they are grouped according to their relations to the world about them. They may, therefore, be gathered into as many (or more than as many) different groups as there are important factors influencing their modes of life. We may classify plants as light-loving and darkness-loving, as requiring free oxygen and not requiring it, and so on.

The most important consideration in classifying seed-plants on ecological grounds is based on their requirements in regard to water. Grouped with reference to this factor in their life, all plants may be classed as:

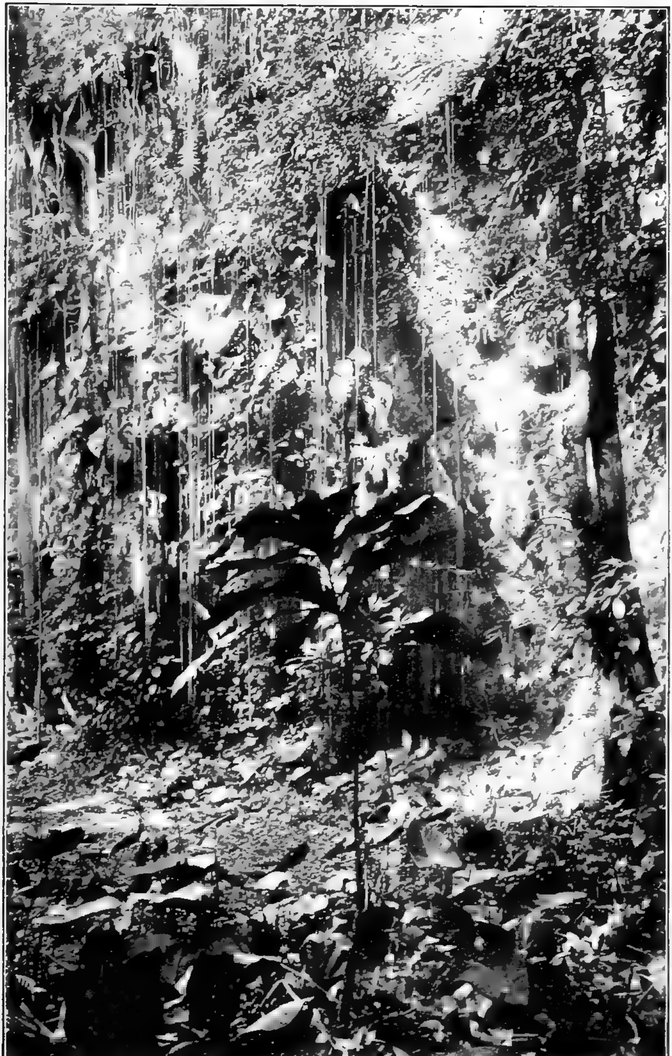
(1) *Hydrophytes*, or water-loving plants.
(2) *Xerophytes*, or drought-loving (or perhaps drought-tolerating) plants.
(3) *Mesophytes*, or plants which thrive best with a moderate supply of water.

These three classes do not fully express all the relations of plants to the water supply, so two others are found convenient.

(4) *Tropophytes*, or seasonal plants which are hydrophytes during part of the year and xerophytes during another part.[1]
(5) *Halophytes*, or salt-marsh plants and "alkali" plants, species which can flourish in a very saline soil.

134. Leaves in Relation to Ecological Classes. — Although the roots and stems of plants which belong to extremely specialized ecological types offer many modifications which adapt them to the kind of life which they have to lead, yet the leaves are still more important in their adaptations. A good botanist can often decide merely by looking at the

[1] The plants which E. Warming, one of the foremost authorities, classes as mesophytes are many of them grouped by another great authority, A. F. W. Schimper, as tropophytes.



Photograph furnished by the Field Museum of Natural History.

PLATE V. An Opening in a Tropical Forest.

leaf of an unknown plant whether it is an alpine, a desert, or a seaside species. This is because of the importance of leaves in disposing of the water taken into the plant (Chapter XIII).

135. Leaves of Hydrophytes.—Not nearly all hydrophytes are aquatics, but some merely prefer very moist soil or moist air. Of the truly aquatic species some have their leaves wholly submerged; others, such as the duckweeds and pond-lilies, have them floating; and still others, like the sedges, the bur reeds, the cat-tails, and the pickerel weeds, have their leaves freely exposed to the air. A few plants have both water leaves and air leaves (Fig. 79). It is generally supposed that the thread-like form of submerged leaves in so many species of aquatics gives them greater capacity to absorb dissolved gases from the water which surrounds them.

FIG. 79. Submerged and Aërial Leaves of a European Crowfoot (*Ranunculus Purshii*). The leaf with thread-like divisions is the submerged one.

136. Leaves of Xerophytes. —In regions where the greatest dangers to vegetation arise from long droughts and the excessive heat of the sun, the leaves of plants usually offer much less surface to the sun and air than is the case in temperate climates, as shown in the Australian blackberry (Fig. 80). Sometimes the blade of the leaf is absent and the expanded petiole answers the purpose of a blade, or, again, foliage leaves are altogether lacking, as in the cactuses (Fig. 81), and the green outer layers of the stem do the work of the leaves.

137. Rolled-Up Leaves. — Leaves which receive but a scanty supply of water are often protected from losing it

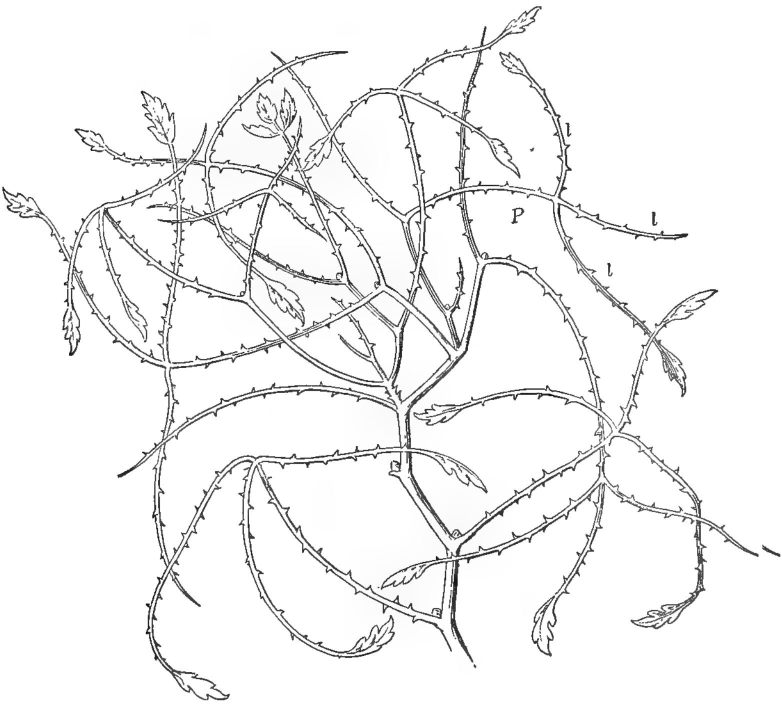


Fig. 80. Xerophytic Leaves of Australian Blackberry.

l, leaflets reduced in many cases to bare midribs, in other cases showing a bit of blade at the end; *P*, petiole.

too rapidly by being rolled up, so that the evaporating, *i.e.*, stomata-containing, surface is on the inside of the roll. Sometimes, as in the crow-berry (Fig. 82), the curled

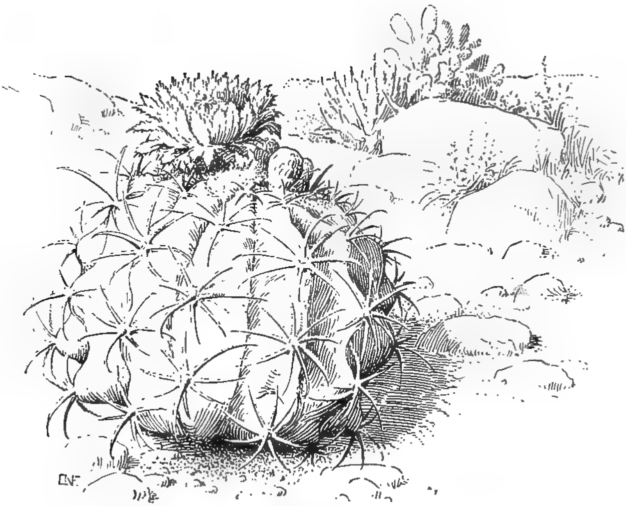


FIG. 81. Melon-Cactus.

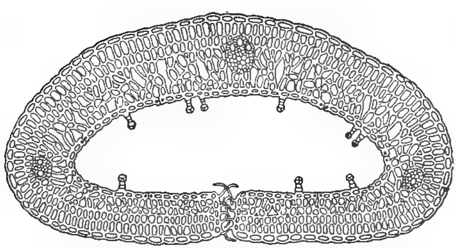


FIG. 82. Cross-Section of Rolled-Up Leaf of Crow-Berry (*Empetrum nigrum*). (Magnified.)

condition is permanent. In other plants, as in Indian corn, the leaf rolls up when the weather is very dry and unrolls again when it receives a better supply of water.

138. Fleshy Leaves. — Many xerophytes and a still larger proportion of halophytes have thick, fleshy leaves, sometimes thick at the base and tapering to a point often nearly cylindrical in form. The common portulaca, the so-called "ice-plants," and the century-plant offer familiar examples of fleshy leaves. Leaves of this form stand exposure to the hottest sunshine, even when the plant is scantily supplied with water.

Fig. 83. Common Pitcher-Plant (*Sarracenia purpurea*).

At the right one of the pitcher-like leaves is shown in cross-section.

139. Leaves of Mesophytes. — The great majority of foliage leaves, such as those of most common garden herbs, grasses, clovers, and so on, belong to this class. They are neither remarkably thick nor thin, expanded nor scanty in surface, and they show no such special adaptations as rolling up to avoid the parching effect of excessive sunshine.

Photograph by William Trelease.

PLATE VI. Tree Yucca in a California Desert.

FIG. 84. Sundew (*Drosera rotundifolia*).

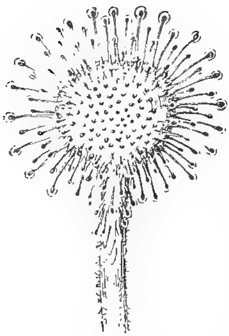


FIG. 85. Blade of Leaf of Sundew. (Somewhat magnified.)

140. Carnivorous Plants. — In the ordinary pitcher-plants (Fig. 83) the leaf appears in the shape of a more or less hooded pitcher. These pitchers are usually partly filled with water, and in this water very many drowned and decaying insects are commonly to be found. The insects have flown or crawled into the pitcher, and, once inside, have been unable to escape on account of the dense growth of bristly hairs about the mouth, all pointing inward and downward. How much the common American pitcher-plants depend for nourishment on the drowned insects in the pitchers is not definitely known, but it is certain that some of the tropical species require such food.[1]

In other rather common plants, the sundews, insects are caught by a sticky secretion which proceeds from hairs on the leaves. In one of the commonest sundews the leaves consist of a roundish blade borne on a moderately long

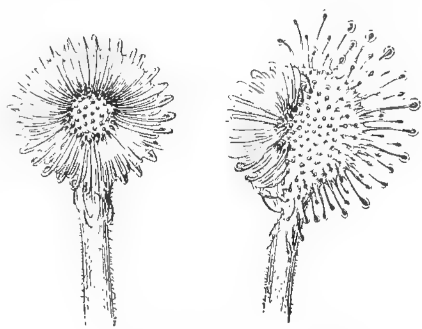


FIG. 86. Leaves of Sundew. (Somewhat magnified.)

The one at the left has all its tentacles closed over captured prey; the one at the right has only half of them thus closed.

[1] Where the *Sarracenia* is abundant it will be found interesting and profitable to make a careful class study of its leaves. See Geddes' *Chapters in Modern Botany*, Chapters I and II.

petiole. On the inner surface and round the margin of the blade (Fig. 85) are borne a considerable number of short bristles, each terminating in a knob which is covered with a clear, sticky liquid. When a small insect touches one of the sticky knobs, he is held fast and the hairs at once begin to close over him, as shown in Fig. 86. Here he soon dies and then usually remains for many days, while the leaf pours out a juice by which the soluble parts of the insect are digested. The liquid containing the digested portions is then absorbed by the leaf and contributes an important part of the nourishment of the plant, while the undigested fragments, such as legs, wing-cases, and so on, remain on the surface of the leaf or may drop off after the hairs let go their hold on the captive insect.

FIG. 87. Venus' Flytrap.

In the Venus' flytrap, which grows in the sandy regions of eastern North Carolina, the mechanism for catching insects is still more remarkable. The leaves, as shown in Fig. 87, terminate in a hinged portion which is surrounded by a fringe of stiff bristles. On the inside of each half of the trap grow three short hairs. The trap is so sensitive that when these hairs are touched it closes rather rapidly and very generally succeeds in capturing the fly or other insect which has sprung it. The imprisoned insect then dies and is digested, somewhat as in the case of those caught by the sundew, after which the trap reopens and is ready for fresh captures.

141. Object of catching Animal Food. — It is easy to understand why a good many kinds of plants have taken to catching insects and absorbing the digested products. Carnivorous, or flesh-eating, plants belong usually to one of two classes as regards their place of growth: they are bog-plants or air-plants. In either case their roots find it difficult to secure much nitrogen-containing food, — that is, much food out of which proteid material can be built up. Animal food, being itself largely proteid, is admirably adapted to nourish the growing parts of plants, and those which could develop insect-catching powers would stand a far better chance to exist as air-plants or in the thin, watery soil of bogs than plants which had acquired no such resources.

142. Destruction of Plants by Animals. — All animals are supported directly or indirectly by plants. In some cases the animal secures its food without much damage to the plant on which it feeds. Browsing on the lower branches of a tree may do it little injury, and grazing animals, if not numerous, may not seriously harm the pasture on which they feed. Fruit-eating animals may even be of much service by dispersing seeds. But seed-eating birds and quadrupeds, animals which, like the hog, dig up fleshy roots, rootstocks, tubers, or bulbs, and eat them, or animals which, like the sheep, graze so closely as to expose the roots of grasses or even of forest trees to be parched by the sun, destroy immense numbers of plants.

So too with leaf-eating insects and snails, which consume great quantities of leaves.

143. Plants of Uneatable Texture. — Whenever tender and juicy herbage is to be had, plants of hard and stringy texture are left untouched. In pastures there grow such perennials as the bracken fern and the hardhack of New England and the ironweed and vervains of the Central States, which are so harsh and woody that the hungriest browsing animal is rarely, if ever, seen to molest them. Still other plants, like the knot-grass and cinquefoil of our dooryards,

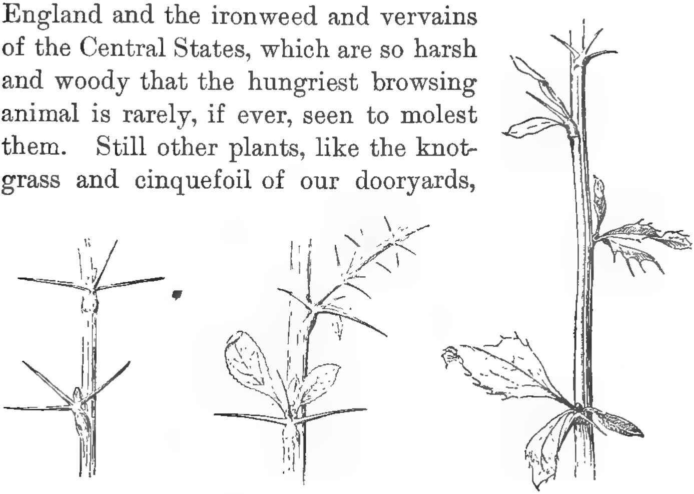


FIG. 88. Spiny Leaves of Barberry.

are doubly safe from their growing so close to the ground as to be hard to graze and from their woody and unpalatable nature. The date-palm (which can easily be raised from the seed in the schoolroom or the laboratory) is an excellent instance of the same uneatable quality found in a tropical or subtropical plant.

144. Plants with Weapons for Defense.[1] — Multitudes of plants, which might otherwise have been subject to the

[1] See Kerner and Oliver's *Natural History of Plants*, Vol. I, p. 430.

attacks of grazing or browsing animals, have acquired what have with reason been called weapons. Among the most conspicuous of these are thorns, which are often modified branches. Thorns, which are really modified leaves, are very perfectly exemplified in the barberry (Fig. 88). It is much commoner to find the leaf extending its midrib or its veins out into spiny points, as the thistle does, or bearing spines or prickles on its midrib, as is the case with the nightshade shown in Fig. 89, and with so many roses.

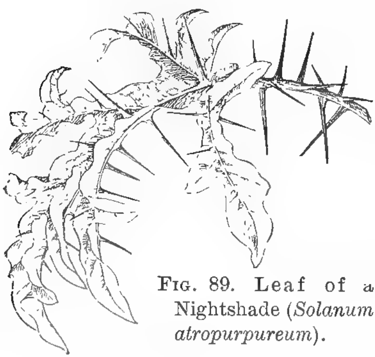


FIG. 89. Leaf of a Nightshade (*Solanum atropurpureum*).

Stipules are not infrequently found occurring as thorns, and in our common locust (Fig. 91) the bud, or the very young shoot which proceeds from it, is admirably protected by the jutting thorn on either side.

145. Pointed, Barbed, and Stinging Hairs. — Needle-pointed hairs are an efficient defensive weapon of many plants. Sometimes these hairs are roughened, like those of the bugloss (Fig. 92, *b*); sometimes they are decidedly barbed. If the barbs are well developed, they may cause the hairs to travel far into the flesh of animals and cause intense pain. In the nettle (Fig. 92, *a*) the hairs are efficient stings, with a brittle tip, which on breaking off exposes a sharp, jagged tube full of irritating fluid. These tubular hairs, with their poisonous contents, will be found sticking in the skin of the hand or the face after incautious contact with nettles, and the violent itching which follows is only too familiar to most people.

146. Cutting Leaves. — Some grasses and sedges are generally avoided by cattle because of the sharp cutting edges of their leaves, which will readily slit the skin of one's hand if they are drawn rapidly through the fingers. Under the microscope the margins of

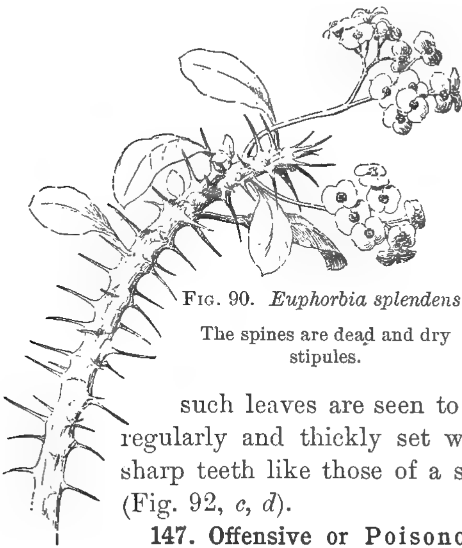


Fig. 90. *Euphorbia splendens.*

The spines are dead and dry stipules.

such leaves are seen to be regularly and thickly set with sharp teeth like those of a saw (Fig. 92, *c*, *d*).

147. Offensive or Poisonous Plants. — A disgusting smell is one of the common safeguards which keep plants from being eaten. The dog-fennel, the hound's-tongue (*Cynoglossum*), the Martynia, and the tomato-plant are common examples of rank-smelling plants which are offensive to most grazing animals and so are let alone by them. Oftentimes, as in the case of the jimson weed (*Datura*), the tobacco-plant, and the poison hemlock (*Conium*), the smell serves as a warning of the poisonous nature of the plant. A bitter, nauseating, or biting taste protects many plants from destruction by animals.

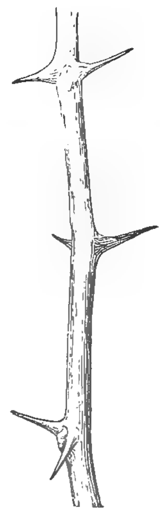


Fig. 91. Thorn Stipules of Locust.

Buckeye, horse-chestnut, and buckthorn leaves are so bitter that browsing animals and most insects let them alone. Tansy, ragweed, boneset, southernwood, and wormwood are safe for the same reason. The nauseous taste of

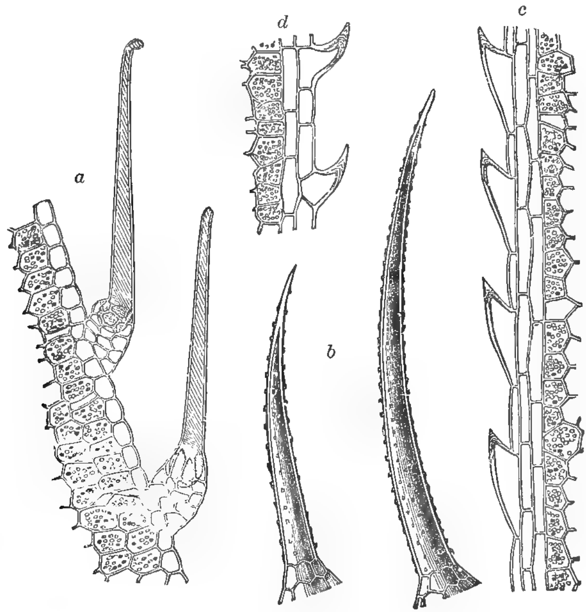


FIG. 92. Stinging Hairs and Cutting Leaves. (All much magnified.)

a, stinging hairs on leaf of nettle; *b*, bristle of the bugloss; *c*, barbed margin of a leaf of sedge; *d*, barbed margin of a leaf of grass.

many kinds of leaves and stems, such as those of the potato, and the fiery taste of horse-radish, make these substances uneatable for most animals.

Poisonous plants are usually shunned by grown-up animals, though the young ones will sometimes eat such plants and may be killed by them.

CHAPTER XIII

MINUTE STRUCTURE OF LEAVES; FUNCTIONS OF LEAVES

148. Leaf of Lily. — A good kind of leaf with which to begin the study of the microscopical structure of leaves in general is that of the lily.[1]

149. Cross-Section of Lily Leaf. — The student should first examine with the microscope a cross-section of the leaf, that is, a very thin slice, taken at right angles to the upper and under surfaces and to the veins. This will show:

(*a*) The upper epidermis of the leaf, a thin, nearly transparent membrane.

(*b*) The intermediate tissues.

(*c*) The lower epidermis.

Use a power of from 100 to 200 diameters. In order to ascertain the relations of the parts and to get their names, consult Fig. 93. Your section is by no means exactly like the figure; sketch it. Label properly all the parts shown in your sketch.

Are any differences noticeable between the upper and the lower epidermis? between the layers of cells immediately adjacent to each?

150. Under Surface of Lily Leaf. — Examine with a power of 200 or more diameters the outer surface of a piece of epidermis from the lower side of the leaf.[2] Sketch carefully, comparing your sketch with Fig. 94, *B*, and labeling it to agree with that figure.

[1] Any kind of lily will answer.

[2] The epidermis may be started with a sharp knife, then peeled off with small forceps, and mounted in water for microscopical examination.

151. Stomata. — A *stoma* is a microscopic pore or slit in the epidermis. It is bounded and opened and shut by guard-cells (Fig. 94, *g*), usually two in number. These

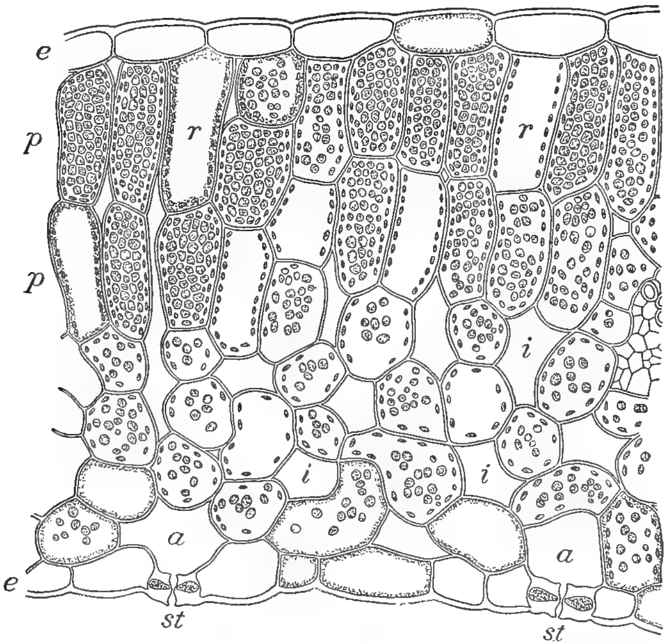


FIG. 93. Vertical Section of the Leaf of the Beet. (Much magnified.)
e, epidermis; *p*, palisade-cells (and similar elongated cells); *r*, cells filled with red cell-sap; *i*, intercellular spaces; *a*, air spaces communicating with the stomata; *st*, stomata, or breathing pores.

are generally somewhat kidney-shaped and become more or less curved as they are fuller or less full of water (see Sect. 158).

In the case of an apple tree, where the epidermis of the lower surface of the leaf contains about 24,000 stomata to the square inch, or the black walnut, with nearly 300,000 to the square inch, the total number on a tree is inconceivably large.

152. Uses of the Parts examined. — It will be most convenient to discuss the uses of the parts of the leaf a little later, but it will make matters simpler to state at once that the epidermis serves as a mechanical protection to the parts beneath and prevents excessive evaporation, that the palisade-cells (which may not be made out very clearly in a roughly prepared section) hold large quantities of the green coloring matter of the leaf in a position where it can receive enough but not too much sunlight, and that the cells of the spongy parenchyma share the work of the palisade-cells, besides evaporating much water. The stomata admit air to the interior of the leaf (where the air spaces serve to store and to distribute it), they allow oxygen and carbonic

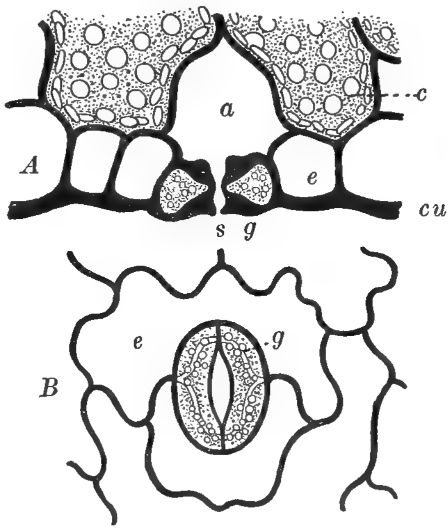


FIG. 94. A Stoma of Thyme. (Greatly magnified.)

A, section at right angles to surface of leaf; *B*, surface view of stoma. *cu*, cuticle; *g*, guard-cells; *s*, stoma; *e*, epidermal cells; *a*, air chamber; *c*, cells of spongy parenchyma with grains of chlorophyll.

acid gas to escape, and by closing completely they may greatly check the loss of water from the plant.

153. Chlorophyll as found in the Leaf. — Slice off a little of the epidermis from some such soft, pulpy leaf as that of the common field sorrel,[1] live-for-ever, or spinach; scrape from the exposed portion a very little of the green pulp; examine with the highest power attainable with your microscope, and sketch several cells. Also study the chlorophyll in a small moss leaf, *e.g.*, of *Mnium*.

Notice that the green coloring matter is not uniformly distributed, but that it is collected into little particles called *chlorophyll bodies* (Figs. 93, 94).

154. Woody Tissue in Leaves. — The veins of leaves consist of fibro-vascular bundles containing wood and vessels much like those of the stem of the plant. Indeed, these bundles in the leaf are continuous with those of the stem, and consist merely of portions of the latter, looking as if unraveled, which pass outward and upward from the stem into the leaf under the name of *leaf-traces*. These traverse the petiole often in a somewhat irregular fashion. It is now easy to see that the dots noted on the leaf-scars of the horse-chestnut, the *Ailanthus* (Fig. 49), and other trees, are merely the spots at which the leaf-traces passed from stem to petiole.

155. Experimental Study of Functions of Leaves. — The most interesting and profitable way in which to find out what work leaves do for the plant is by experimenting upon them. Much that relates to the uses of leaves is not readily shown in ordinary class-room experiments, but some things can readily be demonstrated in the experiments which follow.

[1] *Rumex Acetosella.*

EXPERIMENT XIV

Transpiration. — Take two twigs or leafy shoots of any thin-leaved plant;[1] cover the cut end of each stem with a bit of grafting wax[2] to prevent evaporation from the cut surface. Put one shoot into a fruit jar and leave in a warm room, screw the top on, put the other beside it, and allow both to remain some hours. Examine the relative appearance of the two, as regards wilting, at the end of the time.

Which shoot has lost most? Why? Has the one in the fruit jar lost any water? To answer this question put the jar (without opening it) into a refrigerator, or, if the weather is cold, out of doors for a few minutes, and examine the appearance of the inside of the jar. What does this show?[3]

156. Uses of the Epidermis.[4] — The epidermis, by its toughness, tends to prevent mechanical injuries to the leaf, while by the transformation of a portion of its outer layers into a corky substance it greatly diminishes the loss of water from the general surface. In most cases, as in the india-rubber tree, the epidermal cells (and often two or three layers of cells beneath these) are filled with water, and thus serve as reservoirs from which the outer parts of the leaf and the stem are at times supplied.

In many cases, noticeably in the cabbage, the epidermis is covered with a waxy coating which doubtless increases the power of the leaf to retain needed moisture, and which certainly prevents rain or dew from covering the leaf-surfaces, especially the lower surfaces, so as to prevent the operation of the stomata. Many common plants, like

[1] Hydrangea, squash, melon, or cucumber is best; many other kinds will answer very well.

[2] Grafting wax may be bought of nurserymen or seedsmen.

[3] If the student is in doubt whether the jar filled with ordinary air might not behave in the same way, the question may be readily answered by putting a sealed jar of air into the refrigerator.

[4] See Kerner and Oliver's *Natural History of Plants*, Vol. I, pp. 273–362.

the meadow rue and the nasturtium, possess this power to shed water to such a degree that the under surface of the leaf is hardly wet at all when immersed in water ; the air-bubbles on the leaves then give them a silvery appearance.

157. Hairs on Leaves. — Many kinds of leaves are more or less hairy or downy, as those of the mullein, the "mullein pink," many cinquefoils, and other common plants. In some instances this hairiness may be a protection against snails or other small leaf-eating animals, but in other cases it seems to be pretty clear that the woolliness (so often confined to the under surface) is to lessen the loss of water through the stomata.

158. Operation of the Stomata. — During the early morning the stomata usually continue to open gradually until they reach their maximum size for the day and then gradually lessen in size until the minimum width is reached. In some plants the greatest stomatal opening occurs at about 8 A.M. and the least at about 5 P.M. When leaves begin to wilt the stomata soon close tightly. In many plants, especially those with a very thick leaf-epidermis, the process of giving off water from the leaves, *transpiration*, is almost entirely stopped when the stomata are wholly closed. The under side of the leaf, free from palisade-cells and abounding in intercellular spaces, is especially adapted for the working of the stomata, and accordingly we find them in much greater numbers on the lower than on the upper surface. On the other hand, the little flowerless plants known as liverworts, which lie prostrate on the ground, have their air-pores on the upper surface, and here also occur the stomata of the leaves of pond-lilies. In those leaves which stand with their edges nearly vertical, the stomata are distributed somewhat equally on both surfaces. Stomata occur on the epidermis of young stems, being replaced later by the lenticels. Those plants which, like the cactuses, have no ordinary leaves, transpire through the stomata scattered over their general surfaces.

EXPERIMENT XV

Amount of Water lost by Transpiration. — Procure a thrifty hydrangea[1] growing in a small flower-pot. Calculate the area of the leaf-surface by dividing the surface of a piece of tracing cloth into a series of squares one-half inch on a side, holding an average leaf against this, and counting the number of squares and parts of squares covered by the leaf. This area multiplied by the number of leaves will give approximately the total evaporating surface.

Transfer the plant to a glass battery jar of suitable size. Cover the jar with a piece of sheet lead, slit to admit the stem of the plant, invert the jar, and seal the lead to the glass with a hot mixture of beeswax and resin. Seal up the slit and the opening about the stem with grafting wax. A thistle-tube, such as is used by chemists, is also to be inserted, as shown in Fig. 95.[2] The mouth of this should be kept corked when the tube is not in use for watering.

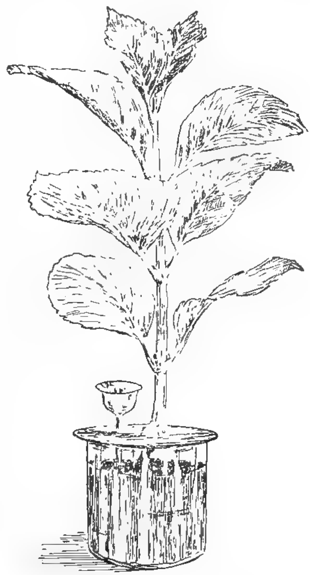


FIG. 95. A Hydrangea for Exp. XV.

[1] The common species of the greenhouses, *Hydrangea Hortensia*.

[2] It will be much more convenient to tie the hydrangea if one has been chosen that has but a single main stem. Instead of the hydrangea the common cineraria, *Senecio cruentus*, does very well.

Water moderately and weigh on a balance that is sensitive to a tenth of a gram. Record the weight, allow the plant to stand in a sunny, warm room for twenty-four hours, and reweigh.

Add just the amount of water which is lost,[1] and continue the experiment in the same manner for several days so as to ascertain, if possible, the effect upon transpiration of varying amounts of water in the atmosphere.

Calculate the loss per 100 square inches of leaf-surface throughout the whole course of the experiment.

Try the effect of supplying very little water, so that the hydrangea will begin to droop, and see whether this changes the relative amount of transpiration. Vary the conditions of the experiment for a day or two as regards temperature, and again for a day or two as regards light, and note the effect upon the amount of transpiration.[2]

EXPERIMENT XVI

Rise of Sap in Leaves. — Put the freshly cut ends of the petioles of several thin leaves of different kinds into small glasses, each containing red ink to the depth of one-quarter inch or more. Allow them to stand for half an hour, and examine by holding up to the light and looking through them to see into what parts the red ink has risen. Allow some of the leaves to remain as much as twelve hours and examine them again. The red-stained portions of the leaf mark the lines along which, under natural conditions, sap rises into it. Cut across (near the petiole or midrib ends) all the principal veins of some kind of large, thin leaf. Then cut off the petiole and at once stand the cut end, to which the blade is attached, in red ink. Repeat with another leaf and stand in water. What do the results teach?

159. Amount of Transpiration. — In order to prevent wilting, the rise of sap during the life of the leaf must

[1] The addition of known amounts of water may be made most conveniently by measuring it in a cylindrical graduate.

[2] When the experiments on the hydrangea have been finished, it should be kept moderately watered and left sealed up until it is needed for a later experiment.

have kept pace with the evaporation from its surface. A little calculation will show that the amount of water thus daily carried off through the foliage of a large tree or the grass-blades on a meadow is enormous. A grass-plant has been found to give off its own weight of water every twenty-four hours, in hot, dry summer weather. This would make about 6½ tons per acre every twenty-four hours for ordinary grass-fields, or rather over 2200 pounds of water from a field 50 × 150 feet (*i.e.*, a city lot).

These large amounts of water are absorbed, carried through the tissues of the plant, and then given off by the leaves simply because the plant-food contained in the soil-water is in a condition so diluted that great quantities of water must be taken in order to secure enough of the mineral and other substances which the plant demands from the soil.

160. Accumulation of Mineral Matter in the Leaf.—Just as a deposit of salt is found in the bottom of a seaside pool of salt water which has been dried up by the sun, so old leaves are found to be loaded with mineral matter left behind as the sap drawn up from the roots is evaporated through the stomata. A bonfire of leaves makes a surprisingly large heap of ashes. An abundant constituent of the ashes of burnt leaves is *silica*, a substance chemically the same as sand. This the plant is forced to absorb along with the potash, compounds of phosphorus, and other useful substances contained in the soil-water; but since the silica is of hardly any value to most plants, it often accumulates in the leaf as so much refuse. Lime is much more useful to the plant than silica, but a far larger quantity of it is absorbed than is needed; hence it, too, accumulates in the leaf.

161. Details of the Work of the Leaf.[1] — A leaf has four important functions to perform:

(1) Fixation of carbon, or photosynthesis.
(2) Assimilation.[2]
(3) Excretion of water.
(4) Respiration.

162. Absorption of Carbon Dioxide and Removal of its Carbon. — Carbon dioxide is a constant ingredient of the atmosphere, usually occurring in the proportion of about three parts in every 10,000 of air, or one thirty-third of one per cent. It is a colorless gas, a compound of two simple substances or elements, carbon and oxygen, the former familiar to us in the forms of charcoal and graphite, the latter occurring as the active constituent of air.

Carbon dioxide is produced in immense quantities by the decay of vegetable and animal matter, by the respiration of animals, and by all fires in which wood, coal, gas, or petroleum is burned.

Green leaves and the green parts of plants, when they contain a suitable amount of potassium salts, have the power of removing carbon dioxide from the air (or in the case of some aquatic plants from water in which it is dissolved), retaining its carbon, and setting free part or all of the oxygen. This process is an important part of the work done by the plant in making over raw materials into food from which it forms its own substance.

[1] See Kerner and Oliver's *Natural History of Plants*, Vol. I, pp. 371–483.
[2] In many works on botany (1) and (2) are both compounded under the term *assimilation*.

EXPERIMENT XVII

Oxygen-Making in Sunlight. — Place a green aquatic plant in a glass jar full of water at a temperature of about 70° Fah. in front of a sunny window.[1] On the surfaces of the plants watch for minute silvery-looking bubbles. These may be partly air but some are oxygen. Remove to a dark closet for a few minutes and examine by lamplight to see whether the rise of bubbles still continues.

This gas may be shown to be oxygen by collecting some of it in a small inverted test-tube filled with water and thrusting the glowing coal of a match just blown out into the gas. It is not, however, very easy to do this satisfactorily before the class.

Repeat the experiment, using water which has been well boiled and then quickly cooled. Boiling removes all the dissolved gases from water, and they are not redissolved in any considerable quantity for many hours.

Ordinary air containing a known per cent of carbon dioxide, if passed very slowly over the foliage of a plant covered with a bell-glass and placed in full sunlight, will, if tested chemically, on coming out of the bell-glass, be found to have lost a little of its carbon dioxide. The pot in which the plant grows must be covered with a lid, closely sealed on, to prevent air charged with carbon dioxide (as the air of the soil is apt to be) from rising into the bell-glass.

163. Disposition made of the Absorbed Carbon Dioxide. — It would lead the student too far into the chemistry of botany to ask him to follow out in detail the changes by which carbon dioxide lets go at least part of its oxygen and gives its remaining portions, namely the carbon and perhaps part of its oxygen, to build up the substance of

[1] *Elodea*, *Myriophyllum*, *Chrysosplenium*, *Potamogeton*, *Fontinalis*, any of the green aquatic flowering plants, or even the common confervaceous plants, known as *pond-scum* or "frog-spit," will do for this experiment.

the plant. Starch is composed of three elements: hydrogen (a colorless, inflammable gas, the lightest of known substances), carbon, and oxygen. Water is composed largely of hydrogen, and therefore carbon dioxide and water contain all the elements necessary for making starch. The chemist cannot put these elements together to form starch, but at suitable temperatures photosynthesis usually ending in starch-making goes on constantly in the green parts of plants when exposed to sunlight and supplied with water and carbon dioxide.[1] The seat of the manufacture is in the chlorophyll bodies, and protoplasm is without doubt the manufacturer, but the process is not understood by chemists or botanists. No carbon dioxide can be taken up and used by plants growing in the dark, nor in an atmosphere containing only carbon dioxide, even in the light.

A very good comparison of the leaf to a mill has been made as follows[2]:

The mill:	Palisade-cells and underlying cells of the leaf.
Raw material used:	Carbon dioxide, water.
Milling apparatus:	Chlorophyll grains.
Energy by which the mill is run:	Sunlight.
Manufactured product:	Starch.
Waste product:	Oxygen.

164. Plants Destitute of Chlorophyll not Starch-Makers. — Aside from the fact that newly formed starch grains are first found in the chlorophyll bodies of the leaf and

[1] Very likely the plant makes sugar first of all and then rapidly changes this into starch. However that may be, the first kind of food made in the leaf and retained long enough to be found there by ordinary tests is starch. See Pfeffer's *Physiology of Plants*, translated by Ewart, Vol. I, pp. 317, 318.

[2] By Professor George L. Goodale.

PLATE VII. American Mistletoe, Parasitic on a Cottonwood.

the green layer of the bark, one of the best evidences of the intimate relation of chlorophyll to starch-making is derived from the fact that plants which contain no chlorophyll cannot make starch from water and carbon dioxide. Parasites, like the dodder, which are nearly destitute of green coloring matter, cannot do this; neither can *saprophytes* or plants which live on decaying or fermenting organic matter, animal or vegetable. Most saprophytes, like the molds, toadstools, and yeast, are flowerless plants of low organization, but there are a few, such as the curious pine-sap (frontispiece) which flourishes on rotten wood or among decaying leaves, that bear flowers and seeds.

165. Detection of Starch in Leaves. — Starch may be found in abundance by microscopical examination of the green parts of growing leaves, or its presence may be shown by testing the whole leaf with iodine solution.

EXPERIMENT XVIII

Occurrence of Starch in Nasturtium Leaves. — Toward the close of a very sunny day collect some bean leaves or leaves of nasturtium (*Tropæolum*). Boil these in water for a few minutes to kill the protoplasmic contents of the cells and to soften and swell the starch grains.

Soak the leaves, after boiling, in strong alcohol for a day or two to dissolve out the chlorophyll, which would otherwise make it difficult to see the blue color of the starch test, if any were obtained. Rinse out the alcohol with plenty of water and then place the leaves for ten or fifteen minutes in a solution of iodine, rinse off with water, and note what portions of the leaf, if any, show the presence of starch.

If convenient try the test with a leaf treated as shown in Fig. 96.

What might this prove about importance of sunlight?

If starch disappeared from between the corks, where did it go?

Review Sects. 17–21, 95–97. Read Sect. 166.

166. Assimilation. — Assimilation means the transformation of food into the tissues of the plant. From the starch in the leaf, grape-sugar or malt-sugar is readily formed, and some of this in turn is apparently combined on the spot with nitrogen, sulphur, and phosphorus. These elements are derived from salts taken up by the roots and transported to the leaves. The details of the process are not understood, but the result of the combination of the sugars or similar substances with suitable (very minute) proportions of nitrogen, sulphur, and phosphorus is to form complex nitrogen compounds. These are not precisely of the same composition as the living protoplasm of plant-cells or as the reserve proteids stored in seeds (Sect. 24), stems (Sect. 91), and other parts of plants, but are readily changed into protoplasm or proteid foods as necessity may demand.

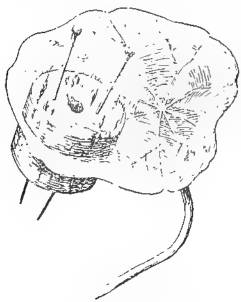


Fig. 96. Leaf of Tropæolum partly covered with Disks of Cork and exposed to Sunlight.

Assimilation is by no means confined to leaves; indeed, most of it, as above suggested, must take place in other parts of the plant.

167. Excretion of Water and Respiration. — Enough has been said in Sect. 159 concerning the former of these processes. *Respiration*, or consuming oxygen and giving off carbon dioxide, is an operation which goes on constantly in plants, as it does in animals, and is necessary to their life. For, like animals, plants get the energy with which they do the work of assimilation, growth, reproduction, and performing their movements from the oxidation

Photograph furnished by the Field Museum of Natural History.

PLATE VIII. A Cypress Swamp.

of such combustible substances as oil, starch, and sugar.[1] In ordinary leafy plants the leaves (through their stomata) are the principal organs for absorption of air, but much air passes into the plant through the lenticels of the bark.

168. The Fall of the Leaf. — In the tropics trees retain most of their leaves the year round; a leaf occasionally falls, but no considerable portion of them drops at any one season.[2] The same statement holds true in regard to our cone-bearing evergreen trees, such as pines, spruces, and the like. But the impossibility of absorbing soil-water when the ground is at or near the freezing temperature would cause the death, by drying up, of trees with broad leaf-surfaces in a northern winter. And in countries where there is much snowfall most broad-leafed trees could not escape injury to their branches from overloading with snow, except by encountering winter storms in as close-reefed a condition as possible. For such reasons our common shrubs and forest trees (except the cone-bearing, narrow-leafed ones already mentioned) are mostly *deciduous*, that is, they shed their leaves at the approach of winter.

The fall of the leaf is preceded by important changes in the contents of its cells.

Much of the starchy, sugary, and protoplasmic contents of the leaf disappears before it falls. These valuable materials have been absorbed by the branches and roots, to be used again the following spring.

The separation of the leaf from the twig is accomplished by the formation of a layer of cork cells across the base of

[1] The necessity of an air supply about the roots of the plant may be shown by filling the pot or jar in which the hydrangea was grown for the transpiration experiment perfectly full of water and noting the subsequent appearance of the plant at periods from twelve to twenty-four hours apart.

[2] Except where there is a severe dry season.

the petiole in such a way that the latter finally breaks off across the surface of the layer. A waterproof scar is thus already formed before the removal of the leaf, and there is no waste of sap dripping from the wound where the leaf-stalk has been removed, and no chance for molds to attack the bark or wood and cause it to decay.

169. Tabular Review of Experiments. — [Continue the table from Sect. 102.]

170. Review Summary of Minute Structure of Leaves.[1]

Layers of tissue seen on a cross-section . . . . . {
Structure of epidermis.
Structure of stomata.
Distribution of stomata.
Structure and distribution of chlorophyll bodies.

171. Review Summary of Functions of Leaves.

Principal uses of . . . .
- fibro-vascular bundles.
- epidermis.
- stomata.
- air spaces.
- palisade-cells.
- spongy parenchyma.
- waxy coating.
- hairs.

Substances received by the leaf . . . .
- from the air.
- from the soil.

Substances manufactured by the leaf.

Substances given off by the leaf . . .
- into the air.
- into the stem.

Mineral substances accumulated in the leaf.
Statistics in regard to transpiration.

[1] Illustrate with sketches and diagrams.

CHAPTER XIV

THE STUDY OF TYPICAL FLOWERS

172. The Flower of the Trillium. — Cut off the flower-stalk rather close to the flower; stand the latter, face down, on the table and draw the parts then shown. Label the green leaf-like parts *sepals*, and the white parts, which alternate with these, *petals*. Turn the flower face up, and make another sketch, labeling the parts as before, together with the yellow enlarged extremities or *anthers* of the stalked organs called *stamens*.

Note and describe the way in which the petals alternate with the sepals. Observe the arrangement of the edges of the petals toward the base, — how many with both edges outside the others, how many with both edges inside, how many with one edge in and one out.

Note the veining of both sepals and petals, — more distinct in which set?[1]

Pull off a sepal and make a sketch of it, natural size; then remove a petal, flatten it out, and sketch it, natural size.

Observe that the flower-stalk is enlarged slightly at the upper end into a rounded portion, the *receptacle*, on which all the parts of the flower rest.

Note how the six stamens arise from the receptacle and their relations to the origins of the petals. Remove the remaining petals (cutting them off near the bottom with a knife), and sketch the stamens, together with the other object, the *pistil*, which stands in the center.

[1] In flowers with delicate white petals the distribution of the fibro-vascular bundles in these can usually be readily shown by standing the freshly cut end of the peduncle in red ink for a short time, until colored veins begin to appear in the petals. The experiment succeeds readily with apple, cherry, or plum blossoms; with white gilliflower the coloration is very prompt. Lily-of-the-valley is perhaps as interesting a flower as any on which to try the experiment, since the well-defined stained stripes are separated by portions quite free from stain, and the pistils are also colored.

Cut off one stamen, and sketch it as seen through the magnifying glass. Notice that it consists of a greenish stalk, the *filament*, and a broader portion, the *anther* (Fig. 108). The latter is easily seen to contain a prolongation of the green filament, nearly surrounded by a yellow substance. In the bud it will be found that the anther consists of two long pouches or *anther-cells*, which are attached by their whole length to the filament and face inward (towards the center of the flower). When the flower is fairly open the anther-cells have already split down their margins and are discharging a yellow, somewhat sticky powder, the *pollen*.

Examine one of the anthers with the microscope, using the two-inch objective, and sketch it.

Cut away all the stamens and sketch the *pistil*. It consists of a stout lower portion, the *ovary*, which is six-ridged or angled, and which bears at its summit three slender *stigmas*.

In another flower, which has begun to wither (and in which the ovary is larger than in a newly opened flower), cut the ovary across about the middle, and try to make out with the magnifying glass the number of chambers or *cells* which it contains. Examine the cross-section with the two-inch objective, sketch it, and note particularly the appearance and mode of attachment of the undeveloped seeds or *ovules* with which it is filled. Make a vertical section of another rather mature ovary, and examine this in the same way.

Using a fresh flower, construct a diagram to show the relation of the parts on an imaginary cross-section, as illustrated in Fig. 116.[1] Construct a diagram of a longitudinal section of the flower, on the general plan of those in Fig. 114, but showing the contents of the ovary.

Make a tabular list of the parts of the flower, beginning with the sepals, giving the order of parts and number in each set.

173. The Flower of the Tulip.[2] — Make a diagram of a side view of the well-opened flower as it appears when standing in sunlight.

[1] It is important to notice that such a diagram is not a picture of the section actually produced by cutting through the flower crosswise at any one level, but that it is rather a *projection* of the sections through the most typical part of each of the floral organs.

[2] *Tulipa Gesneriana.* As the flowers are rather expensive and their parts are large and firm, it is not absolutely necessary to give a flower to each pupil, but some may be kept entire for sketching and others dissected by the class. All the flowers must be single.

Observe that there is a set of outer flower-leaves and a set of inner ones.[1] Label the outer set *sepals* and the inner set *petals*. In most flowers the parts of the outer set are greenish, and those of the inner set of some other color. It is often convenient to use the name *perianth*, meaning around the flower, for the two sets taken together. Note the white waxy bloom on the outer surface of the outer segments of the perianth. What is the use of this? Note the manner in which the inner segments of the perianth arise from the top of the peduncle and their relation to the points of attachment of the outer segments. In a flower not too widely opened, note the relative position of the inner segments of the perianth, — how many wholly outside the other two, how many wholly inside, how many with one edge in and one edge out.

Remove one of the sepals by cutting it off close to its attachment to the peduncle, and examine the veining by holding it up in a strong light and looking through it. Make a sketch to show the general outline and the shape of the tip.

Examine a petal in the same way and sketch it.

Cut off the remaining portions of the perianth, leaving about a quarter of an inch at the base of each segment. Sketch the upright, triangular, pillar-like object in the center and label it *pistil;* sketch the organs which spring from around its base and label these *stamens.*

Note the fact that each stamen arises from a point just above and within the base of a segment of the perianth. Each stamen consists of a somewhat conical or awl-shaped portion below, the *filament*, surmounted by an ovate linear portion, the *anther*. Sketch one of the stamens about twice natural size and label it × 2. Is the attachment of the anther to the filament such as to admit of any nodding or twisting movement of the former? In a young flower, note the two tubular pouches or anther-cells of which the anther is composed, and the slits by which these open. Observe the dark-colored *pollen* which escapes from the anther-cells and adheres to paper or to the fingers. Examine a newly opened anther with the microscope, using the two-inch objective, and sketch it.

Cut away all the stamens and note the two portions of the pistil, a triangular prism, the *ovary*, three roughened scroll-like objects at

[1] Best seen in a flower which is just opening.

the top, and three lobes of the *stigma*. Make a sketch of these parts about twice natural size, and label them × 2. Touch a small camel's-hair pencil to one of the anthers, and then transfer the pollen thus removed to the stigma. This operation is merely an imitation of the work done by insects which visit the flowers out of doors. Does the pollen cling readily to the rough stigmatic surface? Examine this adhering pollen with the two-inch objective, and sketch a few grains of it, together with the bit of the stigma to which it clings. Compare this drawing with Fig. 121. Make a cross-section of the ovary about midway of its length, and sketch the section as seen through the magnifying glass. Label the three chambers shown *cells of the ovary*[1] or *locules*, and the white egg-shaped objects within *ovules*.[2]

Make a longitudinal section of another ovary, taking pains to secure a good view of the ovules, and sketch as seen through the magnifying glass.

Making use of the information already gained and the cross-section of the ovary as sketched, construct a diagram of a cross-section of the entire flower on the same general plan as those shown in Fig. 116.[3]

Split a flower lengthwise[4] and construct a longitudinal section of the entire flower on the plan of those shown in Fig. 114, but showing the contents of the ovary.

174. The Flower of the Buttercup. — Make a diagram of the mature flower as seen in a side view, looking a little down into it. Label the pale greenish-yellow, hairy, outermost parts *sepals*, and the larger bright yellow parts above and within these *petals*, and the yellow-knobbed parts which occupy a good deal of the interior of the flower *stamens*.

Note the difference in the position of the sepals of a newly opened flower and that of the sepals of a flower which has opened as widely as possible. Note the way in which the petals are arranged in relation

[1] Notice that the word *cell* here means a comparatively large cavity, and is not used in the same sense in which we speak of a wood-cell or a pith-cell.

[2] The section will be more satisfactory if made from an older flower, grown out of doors, from which the perianth has fallen. In this case label the contained objects *seeds*.

[3] Consult also the footnote to Sect. 172.

[4] One will do for an entire division of the class.

to the sepals. In an opening flower observe the arrangement of the edges of the petals, — how many entirely outside the others, how many entirely inside, how many with one edge in and the other out.

Cut off a sepal and a petal, each close to its attachment to the flower; place both, face down, on a sheet of paper, and sketch about twice the natural size and label it × 2. Describe the difference in appearance between the outer and the inner surface of the sepal and of the petal. Note the little scale at the base of the petal, inside.

Strip off all the parts from a flower which has lost its petals, until nothing is left but a slender conical object a little more than an eighth of an inch in length. This is the *receptacle* or summit of the peduncle.

In a fully opened flower note the numerous yellow-tipped *stamens*, each consisting of a short stalk, the *filament*, and an enlarged yellow knob at the end, the *anther*. Note the division of the anther into two portions, which appear from the outside as parallel ridges, but which are really closed tubes, the *anther-cells*.

Observe in the interior of the flower the somewhat globular mass (in a young flower almost covered by the stamens). This is a group of *pistils*. Study one of these groups in a flower from which the stamens have mostly fallen off, and make an enlarged sketch of the head of pistils. Remove some of the pistils from a mature head, and sketch a single one as seen with the magnifying glass. Label the little knob or beak at the upper end of the pistil *stigma*, and the main body of the pistil the *ovary*. Make a section of one of the pistils, parallel to the flattened surfaces, like that shown in Fig. 136, and note the partially matured seed within.[1]

[1] After Chapter XV has been completed the teacher may find it advisable to dictate additional studies of some bilaterally symmetrical flowers.

CHAPTER XV

THE FLOWER OF THE HIGHER SEED-PLANTS

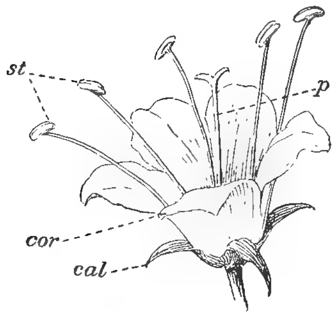


Fig. 97. The Parts of the Flower.

cal, calyx ; *cor*, corolla; *st*, stamens; *p*, pistil.

175. Organs of the Flower. — The parts usually found in a flower of the higher seed-plants are *sepals*, *petals*, *stamens*, and *pistils* (Fig. 97). The sepals, taken together, constitute the *calyx;* the petals, taken together, constitute the *corolla.* The calyx and corolla are collectively known as the *floral envelopes* or *perianth.*

Many flowers consist of five whorls or circles, two of which belong to the perianth,

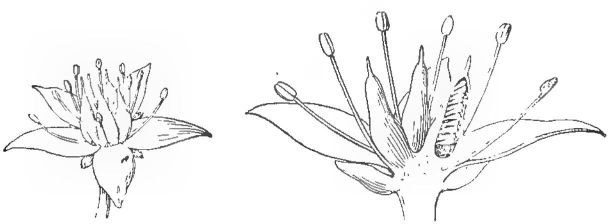


Fig. 98. Flower of Stonecrop.

I, entire flower (magnified). II, vertical section (magnified).

two to the stamens, and one to the pistils. The parts of each whorl alternate in position with those of the preceding or *following one, and all the members of each whorl are alike* (Fig. 98).

176. Suppression and Multiplication of Whorls. — Any whorl or part of a whorl may be suppressed. If one set of parts of the perianth is lacking, this is assumed to be the corolla and the flower is said to be *apetalous* (Fig. 99).

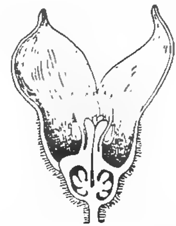


Fig. 99. Apetalous Flower of (European) Wild Ginger.

Multiplication of whorls is particularly frequent among the stamens, but other whorls may also show it (see Figs. 117, 118).

177. Unisexual Flowers. — The stamens and pistils may be produced in separate flowers, which are *unisexual* (often called *imperfect*) flowers. In the very simple unisexual flowers of the willow (Fig. 100) each flower of the catkin (Appendix I, Fig. 6) consists merely of a pistil or a group of (usually two) stamens springing from the axil of a small bract.

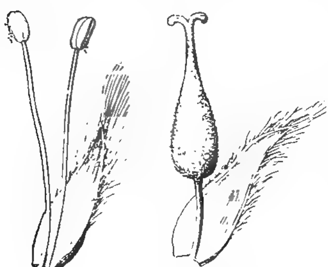


Fig. 100. Flowers of Willow. (Magnified.)
A, staminate flower; *B*, pistillate flower.

Staminate and pistillate flowers may be borne on different plants, as they are in the willow, or they may be borne on the same plant, as in the castor-oil plant, Indian corn, and the begonias. When staminate and pistillate flowers are borne on separate plants, such a plant is said to be *diœcious* (of two households); when both kinds of flower appear on the same individual, the plant is said to be *monœcious* (of one household).

Study of Unisexual Flowers. — Examine, draw, and describe the unisexual flowers of some of the following diœcious plants and one of the monœcious plants:

Diœcious plants	early meadow rue. willow. poplar.
Monœcious plants	walnut, oak, chestnut. hickory, alder, beech. birch, hazel, begonia.

178. Symmetry of the Flower. — Most angiosperms have symmetrical flowers. The simplest are those whose parts are arranged as in Figs. 97, 118, having radial symmetry.

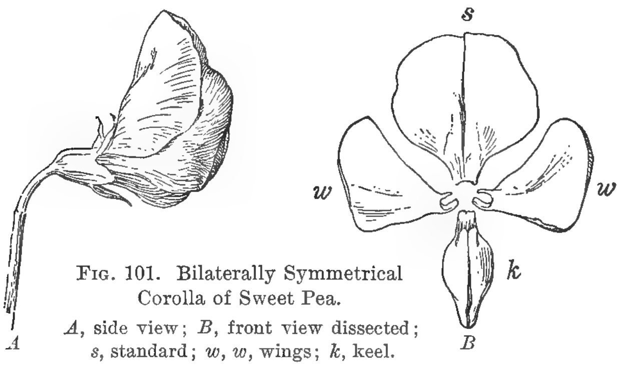


FIG. 101. Bilaterally Symmetrical Corolla of Sweet Pea.

A, side view; *B*, front view dissected; *s*, standard; *w*, *w*, wings; *k*, keel.

A higher type of flower is that which shows *bilateral symmetry*, as in Figs. 101, 128. If the drawing of such a flower were folded along the central line, one half of the drawing would cover and correspond with the other half. Some flowers are wholly irregular, showing no sort of symmetry.

179. The Receptacle. — The parts of the flower are borne on an expansion of the flower-stalk known as the *receptacle*.

Usually, as in Fig. 98, this is only a slight enlargement of the flower-stalk, but in the rose (Fig. 102), the pond lily (Fig. 115), the magnolia, the *Calycanthus*, and a good many other familiar flowers it is large and conspicuous.

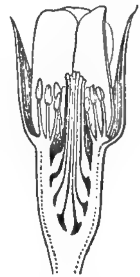


Fig. 102.
A Rose, Longitudinal Section.

180. The Perianth. — The sepals, or divisions of the calyx, are commonly green and somewhat leaf-like. The petals in showy flowers are of many colors, ranging all the way from violet to red. Either whorl of the perianth may be found to have assumed some very peculiar form, to carry out the purpose of the flower, as is briefly explained in Chapter XVII.

Among the lower families of seed-plants with closed ovaries the parts of the perianth are frequently all *distinct*, as shown in Fig. 98. Among the higher families the members of the perianth are often borne upon a tubular or cuplike outgrowth from the receptacle, so that the sepals or petals or both appear to have grown together more or less completely.[1]

When the calyx or the corolla is borne upon a tubular, bowl-shaped, or other extension of the receptacle, there are often divisions, teeth, or lobes at the rim of the tube showing how many sepals or petals the flower possesses. Special names are given to a large number of forms of the

[1] When the parts of the perianth are distinct, the calyx is said to be *chorisepalous* and the corolla *choripetalous*; other terms are *polysepalous* and *polypetalous*. When the receptacle forms a cuplike or tubular outgrowth, so that the teeth or lobes of this alone are sepals or petals, the flower is said to be *synsepalous* or *sympetalous;* other terms are *gamosepalous* or *gamopetalous*. *Choris* means apart, *poly* means many, *syn* means together, *gamos* means marriage. Botanists have until recently used such expressions as "sepals united into a tube," etc., but these are incorrect.

sympetalous corolla and these are of much use in accurate descriptions of seed-plants. A few of these are illustrated

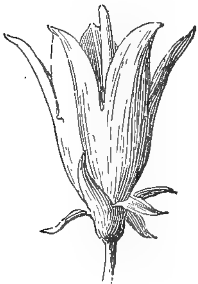


Fig. 103.
Bell-Shaped Corolla of Bell-Flower (*Campanula*).

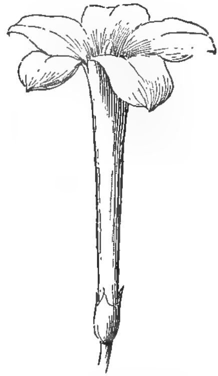


Fig. 104.
Salver-Shaped Corolla of Jasmine. (Magnified.)

Fig. 105.
Wheel-Shaped Corolla of Potato.

in this chapter (Figs. 103–107).

181. Forms of the Stamen; Union of Stamens.—Stamens are of many specialized forms to adapt them to their functions in flowers of various shapes, but many are of the shape shown in Fig. 108. Such a stamen consists of an expanded part, the *anther*, borne on a stalk called the *filament*. Anthers are often nearly or quite *sessile* (i.e. destitute of filaments). Inside the anther is the powdery or pasty substance called *pollen* (Sect. 190).

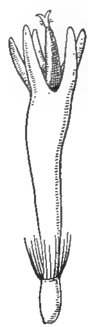


Fig. 106.
Tubular Corolla, from Head of Bachelor's Button.

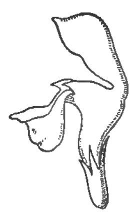


Fig. 107.
Labiate or Ringent Corolla of Dead Nettle.

Stamens may be wholly unconnected with each other, or *distinct*, as shown in Figs. 97, 98, 100, or they may be really or apparently more or less united to each other. In Fig. 109 the stamens have arisen separately, but finally become joined together by their anthers (as is always the case in the family *Compositæ*). In other cases the stamens appear united when they are not really so because they are borne on a ring or tube of tissue, as already explained in connection with the perianth (Sect. 180).

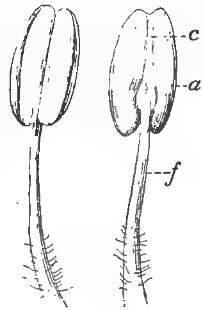


FIG. 108. Parts of a Stamen.

A, front; *B*, back. *a*, anther; *c*, connective; *f*, filament.

Without regard to whether the union is real or apparent, stamens which occur in a single group (the filaments appearing joined) are said to be *monadelphous* (Fig. 110), in two groups *diadelphous* (Fig. 111), in many groups *polyadelphous* (the terms meaning one brotherhood, two brotherhoods, many brotherhoods).

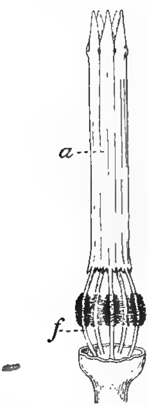


FIG. 109. Stamens of a Thistle, with Anthers united into a Ring.

a, united anthers; *f*, filaments, bearded on the sides.

182. The Carpel. — The simplest form of the organ which bears the structures called *ovules* that are to mature into seeds is known as the *carpel*.

In the lowest of the two great groups of seed-plants, the *gymnosperms* (meaning naked seeds), to which the pines, spruces, cedars, and the like belong, the ovules are borne exposed on the surface of the carpel, which usually has the form of a scale. But in the higher group of seed-plants, the *angiosperms* (meaning seeds in a vessel) the carpels develop cases or chambers, in which the ovules are formed, and which are generally quite closed.

183. The Pistil. — The term *pistil* (Latin for pestle) is applied to the closed structure which contains the ovules and is formed by the carpels of the angiosperms. This is a more general term than carpel, for it applies to organs composed of one or of several carpels. If one-carpeled, a pistil is said to be *simple;* if of two or more carpels, it is *compound.*

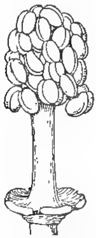


FIG. 110. Monadelphous Stamens of Mallow.

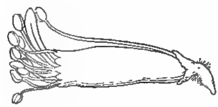


FIG. 111. Diadelphous Stamens of Sweet Pea.

The pistil often consists of the parts shown in Fig. 112, an enlarged hollow portion containing ovules and known as the *ovary*, a stalk-like *style*, and a knob or ridged expansion called the *stigma.* Not infrequently the style is wanting and the stigma is *sessile* (seated) on the ovary.

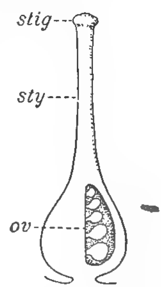


FIG. 112. Parts of the Pistil.

ov, ovary; *sty*, style; *stig*, stigma.

A flower may contain a large number of carpels in the form of simple pistils entirely separate from one another, as in the buttercup and the stonecrop (Fig. 98). When several carpels form a compound pistil, the manner and extent of the union is various. The union generally forms the ovary, although this is sometimes developed in large part as a cuplike or tubular growth under the carpels. Sometimes the union is complete, so that the compound pistil has only one style and stigma. But frequently the styles remain separate, or the styles may be united and the stigmas separate or at least lobed, so as to show of how many carpels the pistil is made up (Figs. 99, 100). Even when there is no external sign to indicate the compound nature of the pistil, it can usually be recognized from a study of a cross-section of the ovary.

184. Locules of the Ovary; Placentas. — Compound ovaries very commonly consist of a number of separate chambers known as *locules.* Fig. 113, *B*, shows a three-loculed ovary seen in cross-section. The ovules are not borne indiscriminately by any part of the lining of the ovary. In one-loculed pistils they frequently grow in a line running along one side of the ovary, as in the pea pod (Fig. 146). The ovule-bearing line is called a *placenta;* in compound pistils there are commonly as many placentas as there are separate carpels joined to make the pistil. Placentas on the wall of the ovary, like those in Fig. 113, *A*, are called *parietal placentas;* those which occur as at *B*, in the same figure, are said to be *central;* and those which, like the form represented in *C* of the same figure, consist of a column rising from the bottom of the ovary are called *free central placentas.*

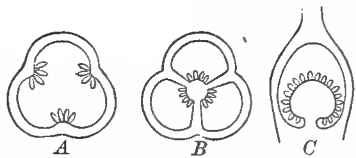


FIG. 113. **Principal Types of Placenta.**

A, parietal placenta; *B*, central placenta; *C*, free central placenta; *A* and *B*, transverse sections; *C*, longitudinal section.

185. Superior, Half-Inferior, and Inferior Ovaries. — When, as in the flower of Fig. 98, the receptacle is rounded or club-shaped and the floral organs arise from it in successive sets, the flower is said to be *hypogynous*, from two Greek words, here applied to mean under the pistil, and the ovaries are said to be *superior* (Fig. 114, I).

When the receptacle is concave, so that the pistil is inserted on the same level with the stamens or lower, but not at all united with the receptacle, the flower is said to be *perigynous* (around the pistil) and the ovary is *half-inferior* (Fig. 114, II). When the ovary is united with the receptacle, the flower is said to be *epigynous* (upon the pistil) or the ovary is *inferior* (Fig. 99).

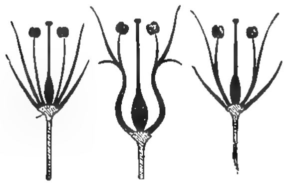


FIG. 114. Insertion of the Floral Organs.

I, hypogynous, all the other parts on the receptacle, beneath the pistil; II, perigynous, petals and stamens apparently growing out of the calyx, around the pistil; III, corolla hypogynous, stamens epipetalous.

186. Floral Diagrams. — Sections (real or imaginary) through the flower lengthwise, like those of Fig. 114, help greatly in giving an accurate idea of the relative position of the floral organs. Still more important in this way are cross-sections, which may be recorded in diagrams like those of Fig. 116.[1]

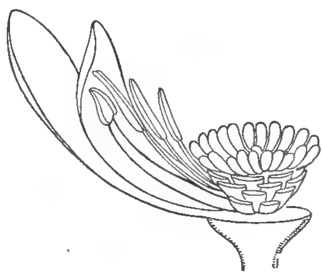


FIG. 115. White Water-Lily.

The inner petals and the stamens growing from the ovary.

In constructing such diagrams it will often be necessary to suppose some of the parts of the flower to be raised or lowered from their true position, so as to bring them into such relations that all could be cut by a single section. This would, for instance, be necessary in making

[1] For floral diagrams see Le Maout and Decaisne's *Traité General de Botanique* or Eichler's *Blüthendiagramme*.

a diagram for the cross-section of the flower of the white water-lily, of which a partial view of one side is shown in Fig. 115.

Construct diagrams of the longitudinal section and the transverse section of several large flowers, following the method indicated in Figs. 114 and 116, but making the longitudinal section show the interior of the ovary.[1]

It is found convenient in diagrams of cross-sections to distinguish the sepals from the petals

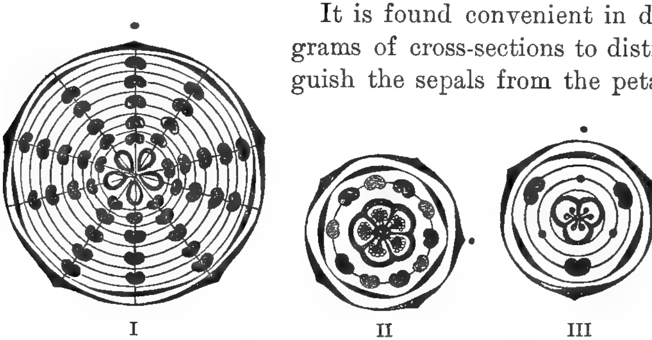


FIG. 116. Diagram of Cross-Sections of Flowers.

I, columbine; II, Heath family; III, Iris family. In each diagram the dot alongside the main portion indicates a cross-section of the stem of the plant. In II every other stamen is more lightly shaded, because some plants of the Heath family have five and some ten stamens.

by representing the former with midribs. The diagrammatic symbol for a stamen stands for a cross-section of the anther, and that for the pistil is a section of the ovary. If any part is lacking in the flower (as in the case of flowers which have some antherless filaments), the missing or abortive organ may be indicated by a dot. In the

[1] Among the many excellent early flowers for this purpose may be mentioned trillium, bloodroot, dogtooth violet, marsh marigold, buttercup, tulip tree, horse-chestnut, Jeffersonia, May-apple, cherry, apple, tulip, daffodil, primrose, wild ginger, cranesbill, locust, bluebell.

diagram of the Iris family (Fig. 116, III) the three dots inside the flower indicate the position of a second circle of stamens, found in most flowers of monocotyledons, but *not* found in this family.

187. Review Summary of Chapter XV.

The organs of the flower and their arrangement.[1]

- Kinds of flower as regards symmetry . . . . .
  - 1.
  - 2.
  - 3.
- The receptacle.
- The perianth .
  - appearance of circles.
  - apparent union of sepals.
  - apparent union of petals.
- The stamens .
  - parts . . . .
    - 1.
    - 2.
    - 3.
  - real union.
  - apparent union.
- The carpel.
- The pistil . .
  - parts . . . .
    - 1.
    - 2.
    - 3.
  - simple pistil.
  - compound pistil.
- The ovary . .
  - types of placenta . . . . . .
    - 1.
    - 2.
    - 3.
  - positions relative to other circles .
    - 1.
    - 2.
    - 3.

[1] Illustrate by sketches when possible.

CHAPTER XVI

TRUE NATURE OF FLORAL ORGANS; DETAILS OF THEIR STRUCTURE; FERTILIZATION

188. The Flower a Shortened and greatly Modified Branch. — In Chapter IX the leaf-bud was explained as being an undeveloped branch, which in its growth would develop into a real branch (or a prolongation of the main stem). Now, since flower-buds appear regularly either in the axils of leaves or as terminal buds, there is reason to regard them as of similar nature to leaf-buds.

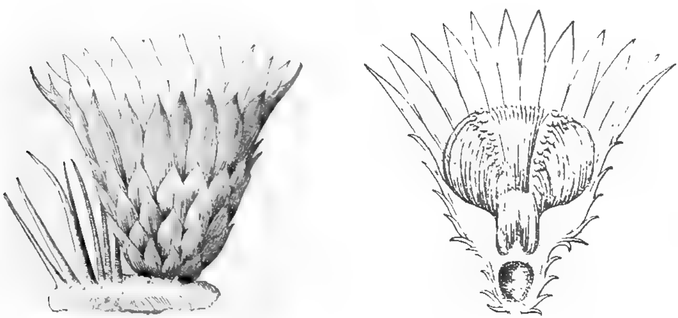


FIG. 117. Transition from Bracts to Sepals in a Cactus Flower.

This would imply that the receptacle corresponds to the axis of the bud shown in Fig. 55, and that the parts of the flower correspond to leaves. There is plenty of evidence that this is really true. Sepals frequently look very much like leaves, and in many cactuses the bracts about the flower are so sepal-like that it is impossible to tell where the bracts end and the sepals begin (Fig. 117). The same thing is true of sepals and petals in such flowers as the white water-lily. In this flower there is a remarkable series of intermediate steps, ranging all the way from petals, tipped with a bit of anther, through stamens with a broad petal-like filament, to regular stamens, as is shown

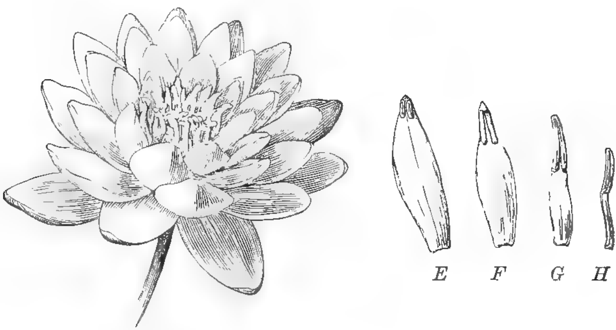


FIG. 118. Transitions from Petals to Stamens in White Water-Lily.
E, *F*, *G*, *H*, various steps between petal and stamen.

in Fig. 118, *E*, *F*, *G*, *H*. The same thing is shown in many double roses. In completely double flowers the stamens and pistils are transformed by cultivation into petals. In the flowers of the cultivated double cherry the pistils occasionally take the form of small leaves, and some roses turn wholly into green leaves.

Summing up, then, we know that flowers are altered and shortened branches: (1) because flower-buds have, as regards position, the same kind of origin as leaf-buds: (2) because all the intermediate steps are found between bracts, on the one hand, and stamens, on the other.

189. Beginnings of the Flower below the Seed-Plants. — A flower, as has just been stated (Sect. 188), is a shortened and modified branch. Its use is to reproduce the plant by the union of male and female cells (produced by the stamens and pistils respectively), as is explained in Sects. 193, 194. We may properly apply the name *flower* to *any portion of stem modified to bear clustered organs which produce cells that unite and mingle their contents to reproduce the plant.*

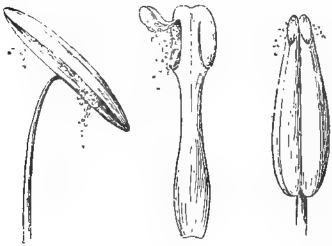
Conelike clusters of reproductive organs are found in the club-mosses (*Lycopodium*) (Fig. 213), and the horse-tails or scouring-rushes (*Equisetum*) (Fig. 211). These simple flowers of plants which grow from spores (Sect. 265), not from seeds with embryos, are much more like the cones of pines and other evergreen trees than like ordinary flowers; for the flowers of spore-plants and the cones of the evergreen trees and shrubs are extremely simple in many ways, and agree also in their spiral arrangement and in having no flower leaves corresponding to sepals and petals. Since the general law among plants and animals is that the more complex forms are descended from simpler ones (Chapter XXVI), it is allowable to suppose that ordinary flowers are remotely descended from some such conelike structures as those of Figs. 211, 213.

The development of flowers has generally been toward making them more showy, thus reducing waste of pollen (Sect. 195 and Chapter XVII).

190. The Anther and its Contents. — Some of the shapes of anthers may be learned from Figs. 108 and 119.[1] Most anthers are thicker than the filament and two-lobed, the halves being joined by a connective (Fig. 108, *c*), which is

[1] See Kerner and Oliver's *Natural History of Plants*, Vol. II, pp. 86–95.

merely a prolongation of the filament. Within each lobe are two pollen-sacs filled with mother cells from which the pollen grains are developed, each cell usually producing four pollen grains. After the anther has matured, the two sacs of each lobe commonly run together into one cavity, which is only partially filled with pollen grains. The shape of the anther and the way in which it opens depend largely upon the way in which the pollen is to be discharged and how it is carried from flower to flower. The commonest method is to have the anther-cells split lengthwise, as in Fig. 119, I. A few anthers open by trap-doors like valves, as in II, and a larger number by little holes at the top, as in III.



I II III

FIG. 119. Modes of discharging Pollen.

I, by longitudinal slits in the anther-cells (amaryllis); II, by uplifted valves (barberry); III, by a pore at the top of each anther-lobe (nightshade).

Sometimes the anthers face outward and open outward, as in the wild ginger (Fig. 98); but more frequently they face and open inward, as in the thistle, the pond lily, and the primrose (Figs. 109, 115, and 134).

The pollen in many plants with inconspicuous flowers, as the evergreen cone-bearing trees, the grasses, rushes, and sedges, is a fine, dry powder. Powdery pollen is adapted to be carried by the wind. In plants with showy flowers the pollen is often somewhat sticky or pasty. Sometimes pollen grains of this kind are bound together in small masses by fine, cobweb-like threads, as in the Milkweed Family (*Asclepiadaceæ*).

Fig. 120 will serve to furnish examples of some of the shapes which pollen grains assume; *c* in the latter figure is perhaps as common a form as any. Each pollen grain consists mainly of a single cell, and is covered by a moderately thick outer wall and a thin inner one. Its contents are thickish protoplasm, full of opaque particles, and usually containing grains of starch and little drops of oil. The knobs on the outer coat, as shown in Fig. 120, *b*, mark

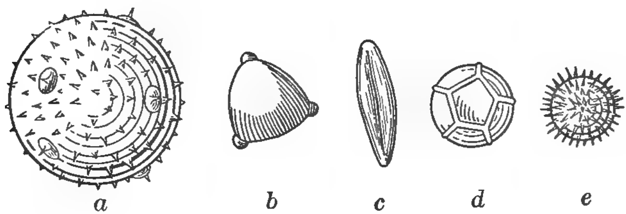


FIG. 120. Pollen Grains. (Very greatly magnified.)

a, pumpkin; *b*, enchanter's nightshade; *c*, Albuca; *d*, pink; *e*, hibiscus.

the spots at which the inner coat of the grain is finally to burst through the outer one, pushing its way out in the form of a slender, thin-walled tube.[1]

191. The Formation of Pollen Tubes. — This can be studied in pollen grains which have lodged on the stigma and there been subjected to the action of its moist surface. It is, however, easier to cause the artificial production of the tubes.

EXPERIMENT XIX

Production of Pollen Tubes. — Place a few drops of suitably diluted syrup with some fresh pollen in a concave cell ground in a microscope slide; cover with a thin glass circle; place under a bell-glass, with a wet cloth or sponge to prevent evaporation of the syrup, and set

[1] See Kerner and Oliver's *Natural History of Plants*, Vol. II, pp. 95–104.

aside in a warm place, or merely put some pollen in syrup in a watch crystal under the bell-glass. Examine from time to time to note the appearance of the pollen tubes. Try several kinds of pollen if possible, using syrups of various strengths. The following kinds of pollen form tubes readily in syrups of the strengths indicated.

Tulip	1 to 3 per cent.
Narcissus	3 to 5 "
Cytisus canariensis (called Genista by florists)	15 "
Chinese primrose	10 "
Sweet pea[1]	10 to 15 "
Tropæolum[1]	15 "

192. Microscopical Structure of the Stigma and Style. — Under a moderate power of the microscope the stigma is seen to consist of cells set irregularly over the surface, and secreting a moist liquid to which the pollen grains adhere (Fig. 121). Beneath these superficial cells and running down through the style (if there is one) to the ovary is spongy parenchyma. In some pistils the pollen tube proceeds through the cell-walls, which it softens by means of a substance which it exudes for that purpose. In other cases (Fig. 122) there is a canal or passage along which the pollen tube travels on its way to the ovule.

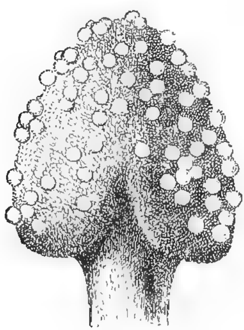


FIG. 121. Stigma of Thorn-Apple (*Datura*) with Pollen. (Magnified.)

[1] The sweet-pea pollen and that of tropæolum are easier to manage than any other kinds of which the author has personal knowledge. If a concaved slide is not available, the cover-glass may be propped up on bits of the thinnest broken cover-glasses. From presence of air or some other reason, the formation of pollen tubes often proceeds most rapidly just inside the margin of the cover-glass.

193. Fertilization. — Fertilization in seed-plants means the union of a sperm nucleus derived from a generative cell of a pollen grain with an egg-cell at the apex of the *embryo sac* (Fig. 124). This process gives rise to a cell

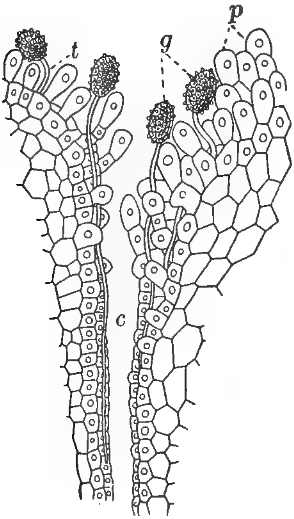


FIG. 122. Pollen Grains producing Tubes, on Stigma of a Lily. (Much magnified.)

g, pollen grains; *t*, pollen tubes; *p*, papillæ of stigma; *c*, canal or passage running toward ovary.

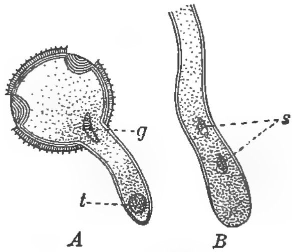


FIG. 123. Germination of Pollen Grain of an Angiosperm. (Much magnified and somewhat diagrammatic.)

A, entire grain, with germination considerably advanced. *B*, tip of pollen tube at a much later stage, after the tube nucleus has disappeared: *g*, the generative cell beginning to enter the tube; *t*, the tube nucleus; *s*, sperm cells formed from the generative cell.

which contains material derived from the pollen and from the egg-cell. In a great many plants the pollen, in order to accomplish the most successful fertilization, must come from another plant of the same kind, not from the individual which bears the ovules that are being fertilized.

Pollen tubes begin to form soon after pollen grains lodge on the stigma. The time required for the tube to penetrate to the ovary varies in different kinds of plants.

Finally the tube enters the opening at the apex of the ovule *m*, in Fig. 124, reaches one of the cells shown at *e*, and transfers a sperm nucleus into this egg-cell. The latter is thus enabled to divide and finally grow into an embryo. This the cell does by forming cell-walls and then increasing by continued subdivision in much the same way in which the cells at the growing point near the tip of the root subdivide.[1]

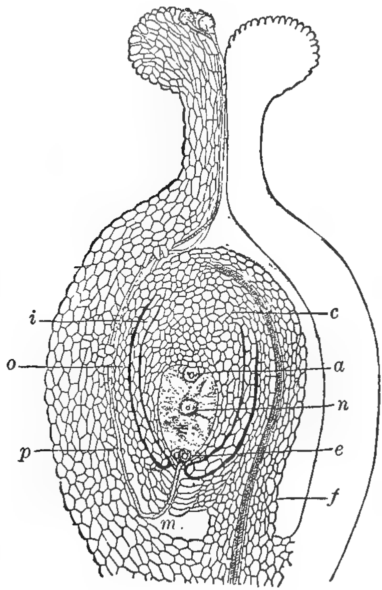


FIG. 124. Diagrammatic Representation of Fertilization of an Ovule.

i, inner coating of ovule; *o*, outer coating of ovule; *p*, pollen tube, proceeding from one of the pollen grains on the stigma; *c*, the place where the two coats of the ovule blend (the kind of ovule here shown is inverted, its opening *m* being at the bottom, and the stalk *f* adhering along one side of the ovule); *a* to *e*, embryo sac, full of protoplasm; *a*, so-called antipodal cells of embryo sac; *n*, central nucleus of the embryo sac; *e*, nucleated cells, one of which, the egg-cell, receives the essential contents of the pollen tube; *f*, funiculus or stalk of ovule; *m*, opening into the ovule

194. Nature of the Fertilizing Process. — The necessary feature of the process of fertilization is *the union of the essential contents of two cells to form a new one from which the future plant is to spring.* This kind of union is found to occur in many cryptogams (Chapters XXIII–XXVII), resulting in the production of a spore capable of growing into a complete plant.

[1] See Strasburger, Noll, Schenk and Karsten's *Text-Book of Botany*, pp. 442–446.

195. Number of Pollen Grains to Each Ovule. — Only one pollen tube is necessary to fertilize each ovule, but so many pollen grains are lost that plants produce many more of them than of ovules. The ratio, however, varies greatly. In the night-blooming cereus there are about 250,000 pollen grains for 30,000 ovules, or rather more than 8 to 1, while in the common garden wisteria there are about 7000 pollen grains to every ovule, and in Indian corn, the cone-bearing evergreens, and a multitude of other plants, many times more than 7000 to 1. These differences depend upon the mode in which the pollen is carried from the stamens to the pistil.

CHAPTER XVII

ECOLOGY OF FLOWERS; POLLINATION

196. Topics of the Chapter. — The ecology of flowers is concerned mainly with the means by which the transference of pollen or *pollination* is effected, and with the ways in which pollen is kept away from undesirable insect visitors and from rain.

197. Cross-Pollination and Self-Pollination.—It was long supposed by botanists that the pollen of any perfect flower needed only to be placed on the stigma of the same flower to insure satisfactory fertilization. At present it is known that probably nearly all attractive flowers, even if they can produce some seed when self-pollinated, do far better when pollinated from the flowers of another plant of the same kind.[1] This important fact was established by a long series of experiments on the number and vitality of seeds produced by a flower when treated with its own pollen, or *self-pollinated*, and when treated with pollen from another flower of the same kind, or *cross-pollinated*.[2]

198. Wind-Pollinated Flowers.[3] — It has already been mentioned that some pollen is dry and powdery and other kinds are more or less sticky. Pollen of the dusty sort is light, and therefore adapted to be blown about by the

[1] See Darwin's *Cross and Self-Fertilization in the Vegetable Kingdom* (especially Chapters I and II).

[2] On dispersion of pollen see Kerner and Oliver, Vol. II, pp. 129–287.

[3] See Newell's *Reader in Botany*, Part II, Chapter VII.

wind. Any one who has been much in cornfields after the corn has "tasseled" has noticed the pale yellow dusty pollen which flies about when a cornstalk is jostled, and which collects in considerable quantities on the blades of the leaves. Corn is monœcious, but fertilization is best accomplished by pollen blown from the "tassel" (stamens) of one plant to the "silk" (pistils) of another plant. The pistil of wind-pollinated flowers is often feathery and thus adapted to catch flying pollen-grains (Fig. 125). Other characteristics of such flowers are the inconspicuous character of their perianth, which is usually green or greenish, the absence of odor and of nectar, the regularity of the corolla, and the appearance of the flowers before the leaves or their occurrence on stalks raised above the leaves.

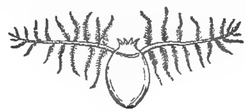


Fig. 125. Pistil of a Grass, provided with a Feathery Stigma, adapted for Wind-Pollination.

Pollen is, in the case of a few aquatic plants, carried from flower to flower by the water on which it floats.

199. Insect-Pollinated Flowers. — Most plants which require cross-pollination depend upon insects as pollen-carriers,[1] and it may be stated as a general fact that the showy colors and markings of flowers and their odors all serve as so many advertisements of the nectar (commonly but wrongly called honey) or of the nourishing pollen which the flower has to offer to insect visitors.

200. Pollen-Carrying Apparatus of Insects.[2] — Ants and some beetles which visit flowers have smooth bodies to which little pollen adheres, so that their visits are often of

[1] A few are pollinated by snails; many more by humming-birds and other birds. [2] See Knuth-Davis' *Handbook of Flower Pollination.*

slight value to the flower; but many beetles, all butterflies and moths, and most bees have bodies roughened with scales or hairs which hold a good deal of pollen entangled. In the common honey-bee (and in many other kinds) the greater part of the insect is hairy, and there are special collecting baskets, formed by bristle-like hairs, on the hind legs (Fig. 126). It is easy to see the load of pollen accumulated in these baskets after such a bee has visited several flowers. Of course the pollen which the bee packs in the baskets and carries off to the hive, to be stored for food, is of no use in pollination.

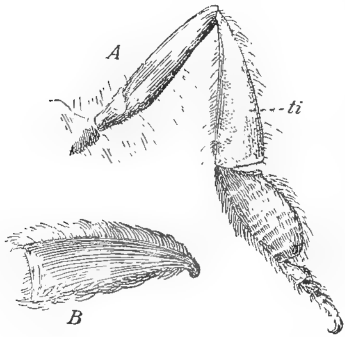


FIG. 126.

A, right hind leg of a honey-bee (seen from behind and within); *B*, the tibia. *ti*, seen from the outside, showing the collecting basket formed of stiff hairs.

201. Nectar and Nectaries. — Nectar is a sweet liquid which flowers secrete for the purpose of attracting insects. After partial digestion in the crop of the bee, nectar becomes honey. Those flowers which secrete nectar do so by means of *nectar glands*, small organs whose structure is something like that of the stigma, situated often near the base of the flower, as shown in Fig. 127. Sometimes the nectar clings in droplets to the surface of the nectar glands; sometimes it is stored in little cavities or pouches called *nectaries*. The pouches at the bases of columbine petals are among the most familiar of nectaries.

202. Odors of Flowers. — The acuteness of the sense of smell among insects is a familiar fact. Flies buzz about the wire netting which covers a piece of fresh meat or a dish of syrup, and bees, wasps, and hornets will fairly besiege the window screens of a kitchen where preserving is going on. Many plants find it possible to attract as many insect visitors as they need without giving off any scent, but small flowers, like the mignonette, and night-blooming ones, like the white tobacco and the evening primrose, are sweet-scented to attract night-flying moths. It is interesting to observe that the majority of the flowers which bloom at night are white, and that they are much more generally sweet-scented than flowers which bloom during the day. A few flowers are carrion-scented (and purplish or brownish colored) and attract flies.

203. Colors of Flowers. — Flowers which are of any other color than green probably in most cases display their colors to attract insects, or occasionally birds.

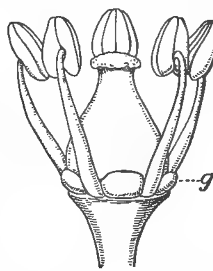


Fig. 127. Stamens and Pistil of the Grape (magnified), with a Nectar Gland, *g*, between Each Pair of Stamens.

It is certain, however, that colors are less important means of attraction than odors, from the fact that insects are extremely near-sighted. Butterflies and moths cannot see distinctly at a distance of more than about five feet, bees and wasps at more than two feet, and flies at more than two and a fourth feet. Probably no insects can make out objects clearly more than six feet away;[1] yet it is quite possible that their attention is attracted by colors at distances greater than those mentioned.[2]

[1] See Packard's *Text-Book of Entomology*, p. 260.

[2] See Lubbock's *Flowers, Fruits, and Leaves*, Chapter I. On the general subject of colors and odors in relation to insects, see Knuth-Davis' *Handbook of Flower Pollination*, Clarendon Press, Oxford.

204. Nectar Guides. — In a large number of cases the petals of flowers show decided stripes or rows of spots of a color different from that of most of the petal. These commonly lead toward the nectaries, and it is possible that such markings point out to insect visitors the way to the nectaries. Following this course, the insect not only secures the nectar which he seeks, but probably leaves pollen on the stigma and becomes dusted with new pollen, which he carries to another flower.

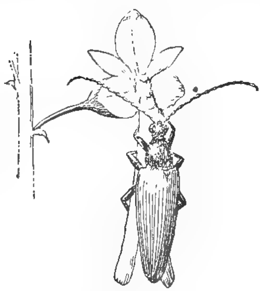


FIG. 128. A Beetle on the Flower of the Twayblade. (Enlarged three times.)

205. Facilities for Insect Visits. — Regular polypetalous flowers have no special adaptations to make them singly accessible to insects, but they lie open to all comers. Bisexual flowers probably always are more or less adapted to particular insect (or other) visitors. The adaptations are extremely numerous; here only a very few of the simpler ones will be pointed out.[1] Where there is a drooping lower petal (or, in the case of a gamopetalous corolla, a lower lip), this serves as a perch upon which flying insects may alight and stand while they explore the flower, as the beetle is doing in Fig. 128. In Fig. 129 one bumblebee stands with her legs partially encircling the lower lip of the dead-nettle flower, while another perches on the sort of grating made by the stamens of the horse-chestnut flower. The honey-bee entering the violet clings to the beautifully bearded portion of the two lateral petals while it sucks the nectar from the *spur* beneath.

[1] See Knuth-Davis' *Handbook of Flower Pollination.*

PLATE IX. Dogwood (*Cornus florida*), with Showy Involucres to attract Insects.

206. Protection of Pollen from Unwelcome Visitors. — It is usually desirable for the flower to prevent the entrance of small creeping insects, such as ants, which carry little pollen and eat a relatively large amount of it. The means adopted to secure this result are many and curious. In some plants, as the common catchfly, there is a sticky

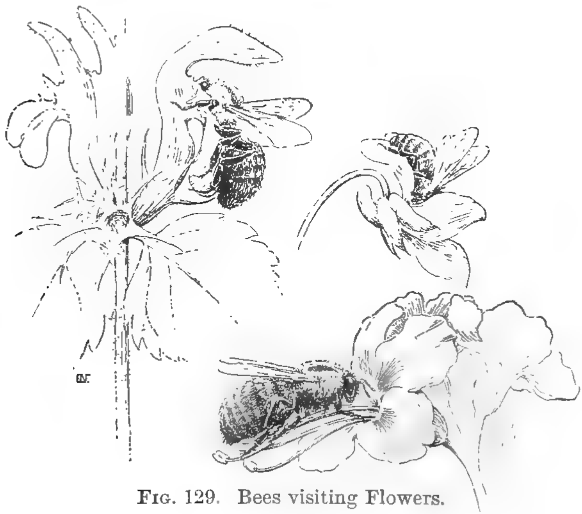


FIG. 129. Bees visiting Flowers.

At the left, a bumblebee on the flower of the dead nettle; below, a similar bee in the flower of the horse-chestnut; above, a honey-bee in the flower of a violet.

ring about the peduncle, some distance below the flowers, and this forms an effectual barrier against ants and like insects. Very frequently the calyx tube is covered with hairs, which are sometimes sticky.

Sometimes the recurved petals or divisions of the corolla stand in the way of creeping insects. In other cases the throat of the corolla is much narrowed or closed by hairs or by appendages.[1] Those flowers which have one or more sepals or petals prolonged into spurs, like the nasturtium and the columbine, are inaccessible to most insects except those which have a tongue or a sucking-tube long

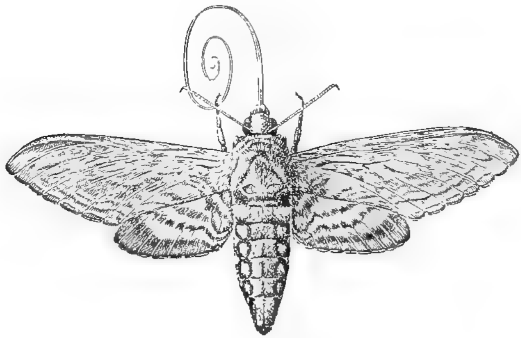


FIG. 130. A Sphinx Moth with a Long Sucking-Tube.

enough to reach to the nectary at the bottom of the spur. The large sphinx moth, shown in Fig. 130, which is a common visitor to the flowers of the evening primrose, is an example of an insect especially adapted to reach deep into long tubular flowers.

207. Bird-Pollinated Flowers. — Some flowers with very long tubular corollas depend entirely upon birds to carry their pollen for them. Among garden flowers the gladiolus, the scarlet salvia, and the trumpet honeysuckle are largely dependent upon humming-birds for their pollination. The wild balsam or jewel-weed and the trumpet-creeper are also favorite flowers of the humming-bird.

208. Prevention of Self-Fertilization. — Diœcious flowers are of course quite incapable of self-pollination.

[1] On protection of pollen, see Kerner and Oliver, Vol. II, pp. 95–109.

Many flowers which appear to be designed to secure self-pollination are almost or quite incapable of it. Frequently the pollen from another plant of the same species prevails over that which the flower may shed on its own pistil, so that when both kinds are placed on the stigma together it is the foreign pollen which fertilizes.

209. Dichogamy; Movements of Stamens. — If the stamens mature at a different time from the pistils, self-pollination is as effectually prevented as though the plant were diœcious. This unequal maturing, or *dichogamy*, occurs in many kinds of flowers. In some, the figwort and the common plantain for example, the pistil develops before the stamens, but usually the reverse is the case. The *Clerodendron*,[1] a tropical African flower (Fig. 131), illustrates in a most striking way the development of stamens before the pistil.

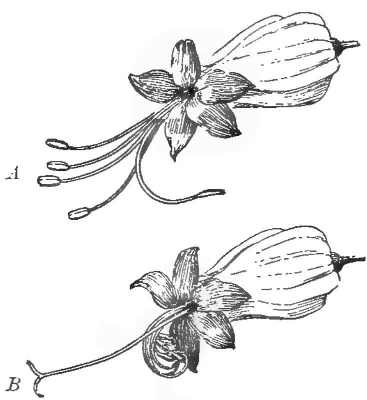


FIG. 131. Flower of *Clerodendron* in Two Stages.

In *A* (earlier stage) the stamens are mature, while the pistil is still undeveloped and bent to one side. In *B* (later stage) the stamens have withered and the stigmas have separated, ready for the reception of pollen.

Besides the slow movements which the stamens and pistil make in such cases as that of the *Clerodendron*, the parts of the flower often, as in the barberry and *Kalmia*, admit of extensive and rather quick movements to assist the insect visitor to become dusted or smeared with pollen.

[1] *C. Thompsoniæ.*

Fig. 132. Flowers of Yucca visited by a Moth.

210. Pollination in Yucca. — The yuccas and allied genera are xerophytes (some of them low plants and others tree-like) which abound especially in the desert and semi-desert portions of the southwestern United States and in Mexico (Plate VI). The flowers are white or whitish, borne in great clusters, and are very conspicuous at night. The stamens are shorter than the pistil, and the pollen is sticky. The pistil consists of three carpels which form a tube stigmatic on its inner surface.

Pollination is impossible without the aid of insects. It is effected by a small moth (*Pronuba*) which throughout the day remains at rest within the flower (Fig. 132).[1] At dusk the female moth begins the work of pollinating the yucca flowers. She clings to the stamens and collects a mass of pollen (Fig. 133). Continuing her work in the same flower, the moth stings one of the ovaries and deposits an egg in an ovule, then mounts[2] to the tip of the pistil and crowds some pollen into the mouth of the stigmatic tube. Self-pollination is thus secured. She then descends to the ovary and deposits another egg, ascends to the stigma to pollinate it, and so on. Each grub when hatched from the egg feeds on the ovule in which the egg was laid; but the ovules are very numerous, so that many of them are left uneaten and ripen into seeds.

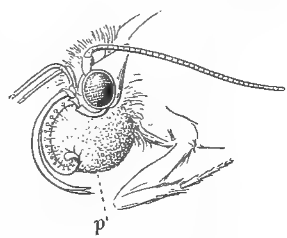


FIG. 133. Head of Yucca Moth. (Magnified.)

p, mass of pollen held in position by spinous appendages of the moth's head.

[1] In the first flower (the lowest) the moth is gathering pollen; in the second she is pollinating the stigma; in the third she is in the position of rest during the day; in the fourth in the position of rest when disturbed; in the fifth ovipositing.

[2] That is, travels away from the receptacle.

211. Flowers with Stamens and Pistils Each of Two Lengths. — The flowers of bluets, partridge-berry, the primroses, and a few other common plants secure cross-pollination by having essential organs of two forms (Fig. 134). Such flowers are said to be *dimorphous* (of two forms). In the short-styled flowers, II, the anthers are borne at the top of the corolla tube and the stigma stands about halfway up the tube. In the long-styled flowers, I, the stigma is at the top of the tube and the anthers are borne about halfway up. An insect pressing its head into the throat of the corolla of II would become dusted with pollen, which would be brushed off on the stigma of a flower like I. On leaving a long-styled flower the bee's tongue would be dusted over with pollen, some of which would necessarily be rubbed off on the stigma of the next short-styled flower that was visited. Cross-pollination is insured since all the flowers on a plant are of one kind, either long-styled or short-styled, and since the pollen is of two sorts, — each kind sterile on the stigma of any flower of similar form to that from which it came.

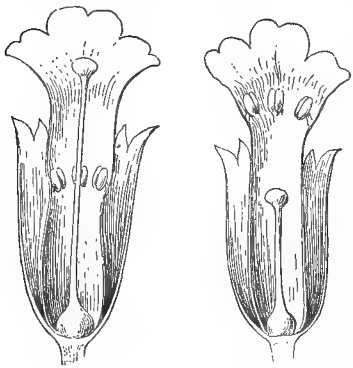


Fig. 134. Dimorphous Flowers of the Primrose.

I, a long-styled flower; II, a short-styled one.

Trimorphous flowers, with long, medium, and short styles, are found in a species of loosestrife.[1]

[1] See Newell's *Reader in Botany*, Part II, pp. 60–63.

212. Studies in Insect Pollination. — The student cannot gather more than a very imperfect knowledge of the details of cross-pollination in flowers without actually watching some of them as they grow, and observing their insect visitors. If the latter are caught and dropped into a wide-mouthed stoppered bottle containing a bit of cotton saturated with chloroform, they will be painlessly killed, and most of them may be identified by any one who is familiar with our common insects. The insects may be observed and classified in a general way as butterflies, moths, bees, flies, wasps, and beetles, without being captured or molested.

Whether these out-of-door studies are made or not, several flowers should be carefully examined and described as regards their arrangements for attracting and utilizing insect visitors (or birds).

213. Cleistogamous Flowers. — In marked contrast with such flowers as those discussed in the preceding sections, which bid for insect visitors or expose their pollen to be blown about by the wind, are certain flowers which remain closed even during the pollination of the stigma. These flowers are called cleistogamous and of course are not cross-pollinated. Usually they occur on plants which also bear flowers adapted for cross-pollination, and in this case the closed flowers are much less conspicuous than the others, yet they produce much seed. Every one knows the ordinary flowers of the violet, but most people do not know that violets very generally, after the blossoming season (of their showy flowers) is over, produce many cleistogamous flowers, as shown in Fig. 135.

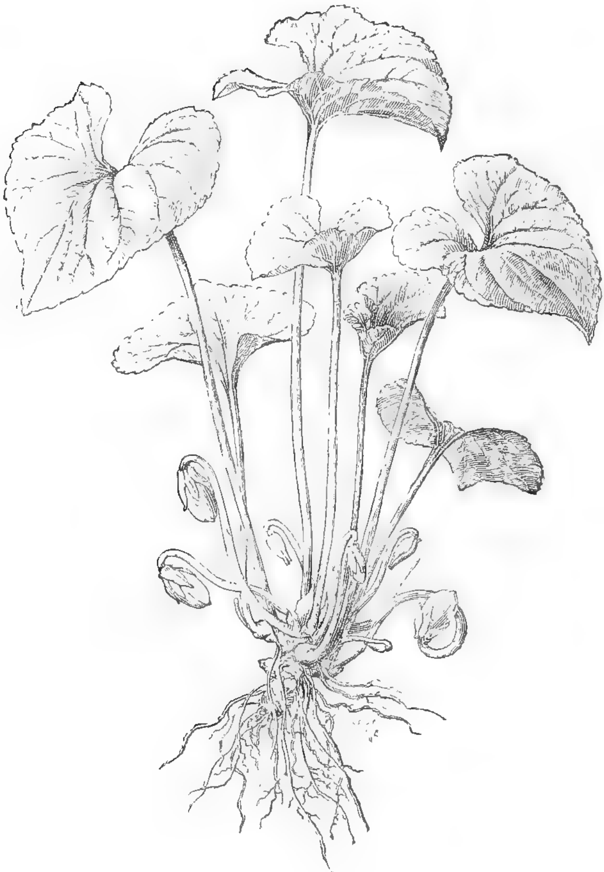


FIG. 135. A Violet with Cleistogamous Flowers.

The objects which look like flower-buds are cleistogamous flowers in various stages of development. The pods are the fruit of similar flowers. The plant is represented as it appears in late July or August, after the ordinary flowers have disappeared.

CHAPTER XVIII

THE STUDY OF TYPICAL FRUITS

214. A Berry, the Tomato.[1] — Study the external form of the tomato, and sketch it, showing the persistent calyx and peduncle.

Cut a cross-section at about the middle of the tomato. Note the thickness of the epidermis (peel off a strip) and of the wall of the ovary. Note the number, size, form, and contents of the cells of the ovary. Observe the thickness and texture of the partitions between the cells. Sketch.

Note the attachments of the seeds to the placentas and the gelatinous, slippery coating of each seed.

The tomato is a typical berry, but its structure presents fewer points of interest than are found in some other fruits of the same general character, so the student will do well to spend a little more time on the examination of such fruits as the orange or the lemon.

215. A Hesperidium, the Lemon. — Procure a large lemon which is not withered, if possible one which still shows the remains of the calyx at the base of the fruit.

Note the color, general shape, surface, remains of the calyx, knob at the portion formerly occupied by the stigma. Sketch the fruit about natural size. Examine the pitted surface of the rind with the magnifying glass and sketch it. Remove the bit of stem and dried-up calyx from the base of the fruit; observe, above the calyx, the knob or *disk* on which the pistil stood. Note with the magnifying glass and count the minute whitish raised knobs at the bottom of the saucer-shaped depression left by the removal of the disk. What are they?

[1] Fresh tomatoes, not too ripe, are to be used, or those which have been kept over from the previous summer in formalin solution. The very smallest varieties, such as are often sold for preserving, are better for study than the larger kinds.

Make a transverse section of the lemon, not more than a fifth of the way down from the stigma end and note:

(1) The thick skin, pale yellow near the outside, white within.

(2) The more or less wedge-shaped divisions containing the juicy pulp of the fruit. These are the matured cells of the ovary; count these.

(3) The thin partition between the cells.

(4) The central column or axis of white pithy tissue.

(5) The location and attachment of any seeds that may be encountered in the section.

Make a sketch to illustrate these points, comparing it with Fig. 141.

Study the section with the magnifying glass and note the little spherical reservoirs near the outer part of the skin, which contain the oil of lemon which gives to lemon peel its characteristic smell and taste. Cut with a razor a thin slice from the surface of a lemon peel, some distance below the section, and at once examine the freshly cut surface with a magnifying glass to see the reservoirs, still containing oil, which, however, soon evaporates. On the cut surface of the pulp (in the original cross-section) note the tubes in which the juice is contained. These tubes are not cells, but their walls are built of cells. Cut a fresh section across the lemon about midway of its length and sketch it, bringing out the same points which were shown in the previous one. The fact that the number of ovary cells in the fruit corresponds with the number of minute knobs in the depression at its base is due to the fact that these knobs mark the points at which fibro-vascular bundles passed from the peduncle into the cells of the fruit, carrying the sap by which the growth of the latter was maintained.

Note the toughness and thickness of the seed-coats. Taste the kernel of the seed.

Cut a very thin slice from the surface of the skin, mount in water, and examine with a medium power of the microscope. Sketch the cellular structure shown and compare it with the sketch of the corky layer of the bark of the potato tuber.

Of what use to the fruit is a corky layer in the skin? (See Sect. 243 for further questions.)

216. A Legume, the Bean-Pod.[1] — Lay the pod flat on the table and make a sketch of it, about natural size. Label *stigma*, *style*, *ovary*, *calyx*, *peduncle*.

Make a longitudinal section of the pod at right angles to the plane in which it lay as first sketched, and make a sketch of the section, showing the partially developed seeds, the cavities in which they lie, and the solid portion of the pod between each bean and the next.

Split another pod so as to leave all the beans lying undisturbed on one-half of it, and sketch that half, showing the beans lying in their natural position and the *funiculus* or stalk by which each is attached to the *placenta*; compare Fig. 146.

Make a cross-section of another pod through one of the beans, sketch the section, and label the placenta (formed by the united edges of the pistil leaf) and the midrib of the pistil leaf.

Break off sections of the pod and determine, by observing where the most stringy portions are found, where the fibro-vascular bundles are most numerous.

Examine some ripe pods of the preceding year,[2] and notice where the *dehiscence*, or splitting open of the pods, occurs, whether down the placental edge, *ventral suture*, the other edge, *dorsal suture*, or both.

217. An Akene, the Fruit of Dock. — Hold in the forceps a ripe fruit of any of the common kinds of dock,[3] and examine with the magnifying glass. Note the three dry, veiny, membranaceous sepals by which the fruit is enclosed. On the outside of one or more of the sepals is found a tubercle or thickened appendage which looks like a little seed or grain. Cut off the tubercles from several of the fruits, put these, with some uninjured ones, to float in a pan of water, and watch their behavior for several hours. What is apparently the use of the tubercle?

[1] Any species of bean (*Phaseolus*) will answer for this study. Specimens in the condition known at the markets as "shell-beans" would be best, but these may not be obtainable in spring. Ordinary "string-beans" will do.

[2] Which may be passed round for that purpose. They should have been saved and dried the preceding autumn.

[3] *Rumex crispus*, *R. obtusifolius*, or *R. verticillatus*. This should have been gathered and dried the preceding summer.

Of what use are the sepals after drying up? Why do the fruits cling to the plant long after ripening?

Carefully remove the sepals and examine the fruit within them. What is its color, size, and shape? Make a sketch of it as seen with the magnifying glass. Note the three tufted stigmas attached by slender threads to the apex of the fruit. What does their tufted shape indicate?

What evidence is there that this seed-like fruit is not really a seed?

Make a cross-section of a fruit and notice whether the wall of the ovary can be seen distinct from the seed-coats. Compare the dock fruit in this respect with the fruit of the buttercup shown in Fig. 136. Such a fruit as either of these is called an *akene*.

CHAPTER XIX

THE FRUIT[1]

218. What constitutes a Fruit. — It is not easy to make a short and simple definition of what botanists mean by the term *fruit.* It has very little to do with the popular use of the word. Briefly stated, the definition may be given as follows: *The fruit consists of the matured ovary and contents, together with any intimately connected parts.* Botanically speaking, the bur of beggar's-ticks (Fig. 148), the three-cornered grain of buckwheat, or such true grains as wheat and oats, are as much fruits as is an apple or a peach.

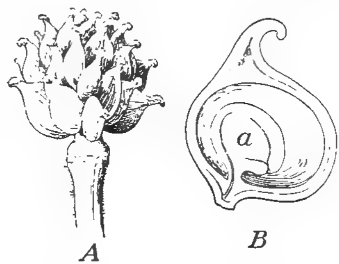


FIG. 136. Akenes of a Buttercup.

A, head of akenes; *B*, section of a single akene (magnified). *a*, seed.

219. Indehiscent and Dehiscent Fruits. — All of the fruits considered in the next three sections are *indehiscent*, that is, they remain closed after ripening. *Dehiscent* fruits when ripe open in order to discharge their seeds; three modes of dehiscence are shown in Fig. 146. The three classes which immediately follow Sect. 222 are all dehiscent.

[1] See Gray's *Structural Botany*, Chapter VII, also Kerner and Oliver's *Natural History of Plants*, Vol. II, pp. 427–438.

220. The Akene. — The one-celled and one-seeded pistils of the buttercup, strawberry, and many other flowers, ripen into a little fruit called an *akene* (Fig. 136). Such fruits, from their small size, their dry consistency, and the fact that they never open, are usually taken for seeds by those who are not botanists.

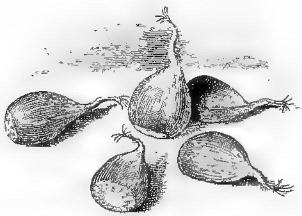


Fig. 137. Chestnuts.

221. The Grain. — Grains, such as corn, wheat, oats, barley, rice, and so on, have the interior of the ovary completely filled by the seed, and the seed-coats and the wall of the ovary are firmly united, as shown in Fig. 6.

222. The Nut. — A nut (Fig. 137) is larger than an akene, usually has a harder shell, and commonly contains a seed which springs from a single ovule of one cell of a compound ovary, which develops at the expense of all the other ovules. The chestnut-bur is a kind of involucre, and so is the acorn-cup. The name *nut* is often incorrectly applied in popular language; for example, the so-called Brazil-nut is really a large seed with a very hard testa.

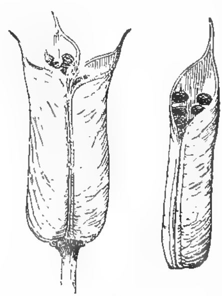


Fig. 138. Group of Follicles and a Single Follicle of the Monkshood.

223. The Follicle. — One-celled, simple pistils, like those of the columbine or the monkshood, often produce a fruit which dehisces along a single suture, usually the ventral one. Such a fruit is called a *follicle* (Fig. 138).

224. The Legume. — A legume is a one-celled pod formed by the maturing of a simple pistil, which dehisces along both of its sutures, as already seen in the case of the bean pod, and illustrated in Fig. 146.

225. The Capsule. — The dehiscent fruit formed by the ripening of a compound pistil is called a *capsule*. Such a fruit may be one-celled, as in the linear pod of the celandine (Fig. 146), or several-celled, as in the fruit of the poppy, the morning-glory, and the jimson weed (Fig. 146).

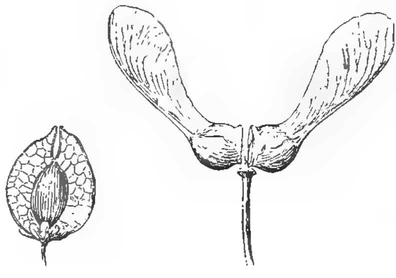


Fig. 139. Winged Fruits. I, elm; II, maple.

226. Dry Fruits and Fleshy Fruits. — In all the cases discussed or described in Sects. 222–225, the wall of the ovary (and the adherent calyx when present) ripens into tissues which are somewhat hard and dry. Often, however, these parts become developed into a juicy or fleshy mass by which the seed is surrounded; hence a general division of fruits into *dry fruits* and *fleshy fruits*.

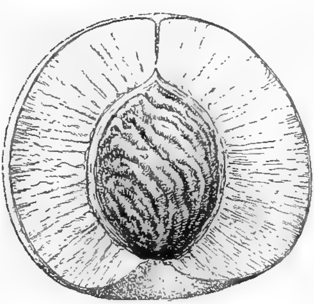


Fig. 140. Longitudinal Section of a Peach.

227. The Stone-Fruit. — In the peach, apricot, plum, and cherry, the *pericarp* or wall of the ovary, during the process of ripening, becomes converted into two kinds of tissue, the outer portion pulpy and edible, the inner portion of almost stony hardness. In common language the hardened inner layer of the pericarp, enclosing the seed, is called the *stone* (Fig. 140); hence the name *stone-fruits.*

228. The Pome. — The fruit of the apple, pear, and quince is called a *pome.* It consists of an ovary of several carpels — the seeds and the tough membrane surrounding them in the *core* — enclosed by a fleshy, edible portion which makes up the main bulk of the fruit. In the apple and the pear much of the fruit is receptacle.

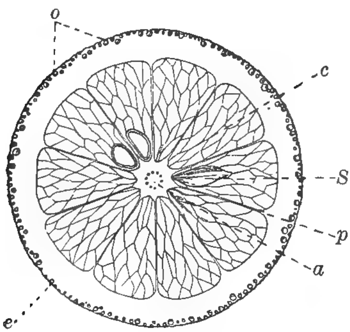


FIG. 141. Cross-Section of an Orange.

a, axis of fruit with dots showing cut-off ends of fibro-vascular bundles; *p*, partition between cells of ovary; *S*, seed; *c*, cell of ovary filled with a pulp composed of irregular tubes full of juice; *o*, oil reservoirs near outer surface of rind; *e*, corky layer of epidermis.

229. The Pepo or Gourd-Fruit. — In the squash, pumpkin, cucumber, and all of the species and varieties of melons and gourds the ripened ovary, together with the thickened receptacle, makes up a peculiar fruit (with a firm outer rind) known as the *pepo.* The relative bulk of greatly enlarged hollow receptacle and of ovary in such fruits is not always the same.

How does the amount of material derived from fleshy and thickened placentæ in the squash compare with that in the watermelon?

230. The Berry. — The berry proper, such as the tomato, grape, persimmon, gooseberry, currant, and so on, consists of a rather thin-skinned, one- to several-celled, *fleshy ovary* and its contents. In the first three cases above mentioned the calyx forms no part of the fruit, but it does in the last two, and in a great number of berries.

The gourd-fruit and the *hesperidium*, such as the orange (Fig. 141), lemon, and lime, are merely decided modifications of the berry proper.

231. Aggregate Fruits. — The raspberry (Fig. 142), blackberry, and similar fruits consist of many carpels, each

I II III

FIG. 142. I, Strawberry; II, Raspberry; III, Mulberry.

of which ripens into a part of a compound mass, which, for a time at least, clings to the receptacle. The whole is called an *aggregate fruit.*

What is the most important difference in structure between a fully ripened raspberry and a blackberry?

232. Accessory Fruits and Multiple Fruits. — Not infrequently, as in the strawberry (Fig. 142), the main bulk of the so-called fruit consists neither of the ripened ovary nor its appendages. Such a combination is called an *accessory fruit.*

Examine with a magnifying glass the surface of a small unripe strawberry, then that of a ripe one, and finally a section of a ripe one, and decide where the separate fruits of the strawberry are found, what kind of fruits they are, and of what the main bulk of the strawberry consists.

The fruits of two or more separate flowers may blend into a single mass, which is known as a *multiple fruit*. Perhaps the best-known edible examples of this are the mulberry (Fig. 142) and the pineapple. The last-named fruit is an excellent instance of the seedless condition which not infrequently results from long-continued cultivation.

233. Summary. — The student may find it easier to retain what knowledge he has gained in regard to fruits if he copies the following synopsis of the classification of fruits, and gives an example of each kind.

- Fruits
  - composition . . .
    - simple.
    - aggregate.
    - accessory.
    - multiple.
  - texture . . . . . .
    - fleshy . . .
      - 1.
      - 2.
      - 3.
    - stone . . .
    - dry . . . .
      - 1.
      - 2.
      - 3.
      - 4.
  - mode of disseminating seed . . . .
    - indehiscent .
      - 1.
      - 2.
      - 3.
    - dehiscent . .
      - 1.
      - 2.
      - 3.

CHAPTER XX

ECOLOGY OF FRUITS; DISPERSAL OF FRUITS AND SEEDS

234. Subjects of the Chapter. — The ecology of fruits and seeds is concerned mainly with the various means by which seeds are protected from decay or from being destroyed by animals, and the methods by which they are enabled to secure transportation and to become planted in localities suitable for their growth. The latter topic, that of seed distribution, is the one which will be discussed in this chapter.

235. Dispersal of Seeds. — Seeds are not infrequently scattered by apparatus by which the plant throws them about. More commonly, however, they depend upon other agencies, such as wind, water, or animals, to carry them. Sometimes the transportation of seeds is due to the structure of the seeds themselves, sometimes to that of the fruit in which they are enclosed; the essential point is to have transportation to a long distance made as certain as possible, to avoid overcrowding.

236. Explosive Fruits. — Some dry fruits burst open when ripe in such a way as to throw their seeds violently about. Interesting studies may be made, in the proper season, of the fruits of the common blue violet, the pansy, the wild balsam, the garden balsam, the cranes-bill, the herb Robert, the witch-hazel, the Jersey tea, and some other common plants. The capsule of the tropical

American sand-box tree bursts open when thoroughly dry with a noise like that of a pistol shot.

237. Winged or Tufted Fruits and Seeds. — The fruits of the ash, box-elder, elm, maple (Fig. 139), and many other trees are provided with an expanded membranous wing. Some seeds, as those of the catalpa and the trumpet-creeper, are similarly appendaged. The fruits of the dandelion, the thistle, the fleabane, and many other plants of the group to which these belong, and the seeds of the willow, the milkweed (*Asclepias*), the willow-herb, and other plants bear a tuft of hairs.

Fig. 143. Fruits of Linden, with a Bract joined to the Peduncle and forming a Wing.

The student should be able, from his own observations on the falling fruits of some of the trees and other plants above mentioned, to answer such questions as the following.

What is the use of the wing-like appendages? of the tufts of hairs?

Which set of contrivances seems to be the more successful of the two in securing this object?

What particular plant of the ones available for study seems to have attained this object most perfectly?

What is one reason why many plants with tufted fruits, such as the thistle and the dandelion, are extremely troublesome weeds?

A few simple experiments, easily devised by the student, may help him to find answers to the questions above given.[1]

[1] See Kerner and Oliver, Vol. II, pp. 833–875; also Beal's *Seed Dispersal*.

PLATE X. Thistle Fruits, adapted for Dispersal by the Wind.

238. Tumbleweeds. — Late in the autumn, fences, particularly on prairie farms that are not carefully tilled, often serve as lodging-places for immense numbers of certain dried-up plants known as tumbleweeds. These blow about over the level surface until the first snow falls

Fig. 144. Russian Thistle.

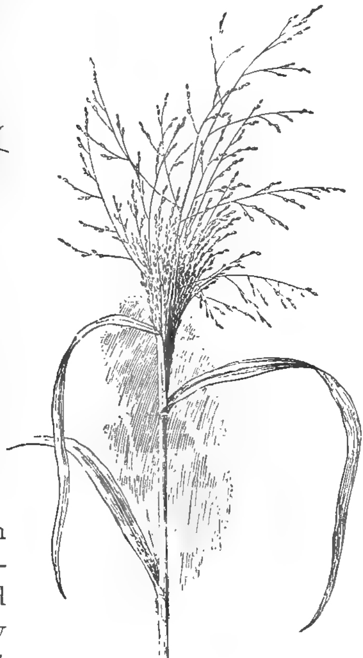
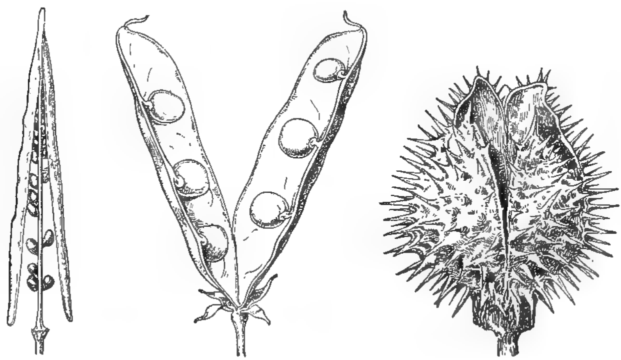


Fig. 145. Panicle of Tickle-Grass, a Common Tumbleweed.

and even after that, often traveling for many miles before they come to a stop, and rattling out seeds as they go. Some of the commonest tumbleweeds are the Russian thistle (Fig. 144), the pigweed (*Amarantus græcizans*), the tickle-grass (Fig. 145), and a familiar pepper-grass (*Lepidium*). In order to make a successful tumbleweed, a plant must be pretty nearly globular in form when fully grown and dried, must be tough and light, must break off near the ground, and drop its seeds only a few at a time as it travels. A single plant of Russian thistle is sometimes as much as three feet high and six feet in diameter and carries not less than two hundred thousand seeds.

239. Many-Seeded Pods with Small Openings. — There are many fruits which act somewhat like pepper-boxes.



I II III

FIG. 146. Three Fruits adapted for Dispersal by the Shaking Action of the Wind.

I, celandine; II, pea; III, jimson weed (*Datura*).

The capsule of the poppy is a good instance of this kind, and the fruit of the lily, monkshood (Fig. 138), columbine, larkspur, and jimson weed (Fig. 146) acts in much the same way. Clamping the dry peduncle of any one of these ripe fruits, so as to hold it upright above the table-top, and then swinging it back and forth, will readily show its efficiency in seed dispersal.

240. Study of Transportation by Water. — Nothing less than a long series of observations by the pond-margin and the brookside will suffice to show how general and important is the work done by water in carrying the seeds of aquatics. An experiment will, however, throw some light on the subject.

EXPERIMENT XX

Adaptation for Transportation by Water. — Collect fruits of as many aquatic, semi-aquatic, or riverside and brookside species of plants as possible, place them on shallow pans of water, and notice what proportion of all the kinds studied will float. Leave them twenty-four hours or more and see whether all the kinds that floated at first are still afloat. Some desirable fruits for this experiment are aquatic grasses, rushes and sedges, polygonums, water-dock, bur-reed, arrowhead, water-plantain, pickerel-weed, alder, button-bush, water-parsnip (*Sium*), water-hemlock (*Cicuta*), water penny-wort (*Hydrocotyle*), lotus (*Nelumbo*).

241. Distances traversed by Floating Seeds. — Ocean currents furnish transportation for the longest journeys that are made by floating seeds. It is a well-known fact that cocoa-palms are among the first plants to spring up on newly formed coral islands. The nuts from which these palms grew may readily have floated a thousand miles or more without injury. On examining a cocoanut with a fibrous husk attached, just as it fell from the tree, it is easy to see how well this fruit is adapted for transportation by water. There are altogether about a hundred drifting fruits known, one (the Maldive nut) reaching a weight of from twenty to twenty-five pounds.

242. Burs. — A large class of fruits is characterized by the presence of hooks on the outer surface. These are sometimes outgrowths from the ovary, sometimes from the calyx, sometimes from an involucre. Their office is to attach the fruit to the hair or fur of passing animals. Often, as in sticktights (Fig. 147), the hooks are comparatively weak, but in other cases, as in the cocklebur (Fig. 147), and still more in the Martynia, the fruit of

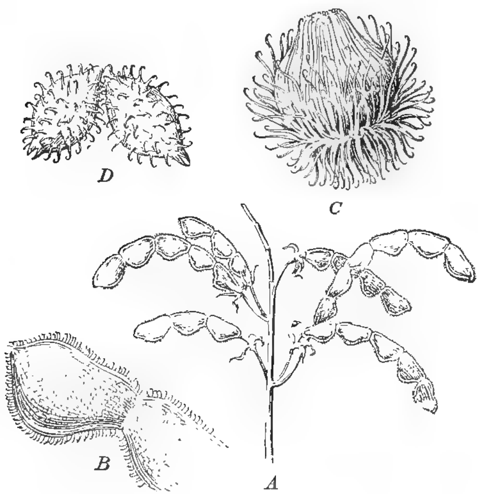


FIG. 147. Burs.

A, sticktights; *B*, sticktights, two segments (magnified); *C*, burdock; *D*, cockleburs.

which in the green condition is much used for pickles, the hooks are exceedingly strong. Cockleburs can hardly be removed from the tails of horses and cattle, into which they have become matted, without cutting out all the hairs to which they are fastened.

Why do bur-bearing plants often carry their fruit until late winter or early spring?

What reason can be given for the fact that the burdock, the cocklebur, the beggar's-ticks, the hound's-tongue, and many other common burs are among the most persistent of weeds?

243. Uses of Stone-Fruits and Fleshy Fruits to the Plant. — Besides the *dry fruits*, of which some of the principal kinds have been mentioned, there are many kinds of *stone-fruits and other fleshy fruits* (Sects. 227–230). Of these the great majority are eatable by man or some of the lower animals, and oftentimes the

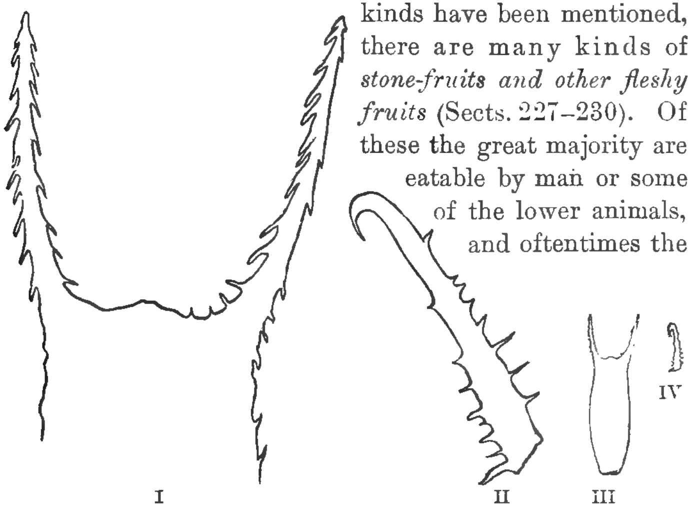


FIG. 148. Barbs and Hooks of Burs.

I, barbed points from fruit of beggar's-ticks (magnified eleven times); II, hook of cocklebur (magnified eleven times); III, beggar's-ticks fruit (natural size); IV, cocklebur hook (natural size).

amount of sugar and other food material which they contain is very considerable. It is a well-recognized principle of botany, and of zoölogy as well, that plants and animals do not make unrewarded outlays for the benefit of other species. Evidently the pulp of fruits is not to be consumed or used as food by the plant itself or (in general) by its seeds. It is worth while, therefore, for the student to ask himself some such questions as these:[1]

(1) Why is the pulp of so many fruits eatable?

(2) Why are the seeds of many pulpy fruits bitter or otherwise unpleasantly flavored, as in the orange?

(3) Why are the seeds or the layers surrounding the seeds of many pulpy fruits too hard to be chewed, or digested, as in the date and the peach?

(4) Why are the seeds of some pulpy fruits too small to be easily chewed, and also indigestible, as in the fig and the currant?

(5) Account for the not infrequent presence of currant bushes or asparagus plants in such localities as the forks of large trees, sometimes at a height of twenty, thirty, or more feet above the ground.

Careful observation of the neighborhood of peach, plum, cherry, or apple trees at the season when the fruit is ripe and again during the following spring, and an examination into the distribution of wild apple or pear trees in pastures where they occur, will help the student who can make such observations to answer the preceding questions. So, too, would an examination of the habits of fruit-eating quadrupeds and of the crop and gizzard of fruit-eating birds during the season when the fruits upon which they feed are ripe.

244. Seed-Carrying purposely done by Animals. — In the cases referred to in the preceding sections, animals have been seen to act as unconscious or even unwilling seed-carriers. Sometimes, however, they carry off seeds with the plan of storing them for food. Ants drag away with

[1] See Kerner and Oliver's *Natural History of Plants*, Vol. II, pp. 442–450.

them to their nests certain seeds which have fleshy growths on their outer surfaces. Afterwards they eat these fleshy parts at their leisure, leaving the seed perfectly fit to grow, as it often does.[1]

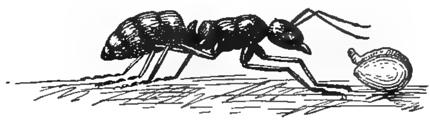


FIG. 149. Seed of Bloodroot with Caruncle or Crest, which serves as a Handle for Ants to hold on to. Ant ready to take the seed.

Squirrels and bluejays are known to carry nuts and acorns about and bury them for future use. These deposits are often forgotten and so get a chance to grow, and in this way a good deal of tree-planting is done.

[1] See Beal's *Seed Dispersal*, pp. 69, 70.

CHAPTER XXI

THE STRUGGLE FOR EXISTENCE AND THE SURVIVAL OF THE FITTEST[1]

245. Weeds. — Any flowering plant which is troublesome to the farmer or gardener is commonly known as a weed. Though such plants are annoying from their tendency to crowd out others useful to man, they are of extreme interest to the botanist on account of this very hardiness. The principal characteristics of the most successful weeds are their ability to live in a variety of soils and exposures, their rapid growth, resistance to frost, drought, and dust, their unfitness for the food of most of the larger animals, in many cases their capacity to accomplish self-pollination in default of cross-pollination, and their ability to produce many seeds and to secure their wide dispersal. Not every weed combines all of these characteristics. For instance, the velvet-leaf or butter-print,[2] common in cornfields, is very easily destroyed by frost; the pigweed and purslane are greedily eaten by pigs, and the ragweed by some horses. The horse-radish does not usually produce any seeds.

It is a curious fact that many plants which have finally proved to be noxious weeds have been purposely introduced into the country. The fuller's teasel, melilot, horse-radish,

[1] See Darwin's *Origin of Species*, Chapters III and IV.

[2] *Abutilon Theophrasti.*

wild carrot, wild parsnip, tansy, oxeye daisy, and field-garlic are only a few of the many examples of very troublesome weeds which were at first planted for use or for ornament.

246. Origin of Weeds.[1] — By far the larger proportion of our weeds are not native to this country. Some have been brought from South America and from Asia, but most of the *introduced* kinds come from Europe. The importation of various kinds of grain and of garden-seeds, mixed with seeds of European weeds, will account for the presence of many of the latter among us. Others have been brought over in the ballast of vessels. Once landed, European weeds have succeeded in establishing themselves in so many cases, because they were superior in vitality and in their power of reproduction to our native plants. This may not improbably be due to the fact that the European and western Asiatic vegetation, much of it consisting from very early times of plants growing in comparatively treeless plains, has for ages been habituated to flourish in cultivated ground and to contend with the crops which are tilled there.

247. Plant Life maintained under Difficulties. — Plants usually have to encounter many obstacles even to their bare existence. For every plant which succeeds in reaching maturity and producing a crop of spores or of seeds there are hundreds or thousands of failures, as it is easy to show by calculation. The morning-glory (*Ipomœa purpurea*) is only a moderately prolific plant, producing, in an ordinary soil, somewhat more than three thousand seeds.[2] If all these seeds were planted and grew, there would

[1] See the article *Pertinacity and Predominance of Weeds*, in *Scientific Papers of Asa Gray*, selected by C. S. Sargent, Vol. II, pp. 234–242.

[2] Rather more than three thousand two hundred by actual count and estimation.

be three thousand plants the second summer sprung from the single parent plant. Suppose each of these plants to bear as the parent did, and so on, then there would be:

9,000,000 plants the third year.
27,000,000,000 plants the fourth year.
81,000,000,000,000 plants the fifth year.
243,000,000,000,000,000 plants the sixth year.
729,000,000,000,000,000,000 plants the seventh year.

It is not difficult to see that the offspring of a single morning-glory plant would, at this rate, soon actually cover the entire surface of the earth. The fact that morning-glories do not occupy any larger amount of territory than they do must therefore depend upon the fact that the immense majority of their seeds are not allowed to grow into mature plants.

There are many plants which would yield far more surprising results in a calculation similar to that just given than are afforded by the morning-glory. For instance, a foxglove capsule contains on an average nearly 1800 seeds. A small foxglove plant bears from 140 to 200 capsules and a large one from 530 to 700. Therefore a single plant may produce over 1,250,000 seeds. A single orchid plant[1] has been shown to produce over 10,000,000 seeds.

248. Importance of Dispersal of Seeds. — It is clear that any means of securing the wide distribution of seeds is of vital importance in continuing and increasing the numbers of any kind of plant, since in this way destruction by overcrowding and starvation will be lessened.

A few of the means of transportation of seeds have been described in Sects. 235–244, but the cases are so numerous

[1] *Maxillaria;* see Darwin's *Fertilization of Orchids*, Chapter IX

and varied that a special treatise might well be devoted to this subject alone.

249. Destruction of Plants by Unfavorable Climates. — Land-plants throughout the greater part of the earth's surface are killed in enormous numbers by excessive heat and drought, by floods, or by frost. After a very dry spring or summer the scantiness of the crops, before the era of railroads which nowadays enable food to be brought in rapidly from other regions, often produced actual famine. Wild plants are not observed so carefully as cultivated ones are, but almost every one has noticed the patches of grass, apparently dead, in pastures and the withered herbaceous plants everywhere through the fields and woods after a long drought.

Floods destroy the plants over large areas by drowning them, by sweeping them bodily away, or by covering them with sand and gravel. Frosts kill many annual plants before they have ripened their seeds, and severe and changeable winters sometimes kill perennial plants.

250. Destruction by Other Plants. — Overcrowding is one of the commonest ways in which plants get rid of their weaker neighbors. If the market-gardener sows his lettuce or his beets too thickly, few perfect plants will be produced, and the same kind of effect is brought about in nature on an immense scale. Sometimes plants are overshadowed and stunted or killed by the growth all about them of others of the same kind; sometimes it is plants of other kinds that crowd less hardy ones out of existence.

Whole tribes of parasitic plants, some comparatively large, like the dodder and the mistletoe, others microscopic, like blights and mildews, prey during their entire lives upon other plants.

251. Adaptations to meet Adverse Conditions. — Since there are so many kinds of difficulties to be met before the seed can grow into a mature plant and produce seed in its turn, and since the earth's surface offers such extreme variations as regards heat, sunlight, rainfall, and quality of soil, it is evident that there is a great opportunity offered for competition among plants. Of several plants of the same kind, growing side by side, where there is room for but one full-grown one, all may be stunted, or one may develop more rapidly than the others, starve them out, and shade them to death. Of two plants of different kinds, the hardier will crowd out the less hardy, as ragweed, pigweed, and purslane do with ordinary garden crops. Weeds like these are rapid growers, stand drought or shade well, will bear to be trampled on, and, in general, show remarkable toughness of organization.

Plants which can live under conditions that would be fatal to most others will find much less competition than the rank and file of plants are forced to encounter. Lichens growing on barren rocks are thus situated, and so are the numerous species of blue-green algæ (Sect. 277) which are found growing in hot springs, as in those of the Yellowstone National Park, at temperatures of 140° or more.

252. Examples of Rapid Increase. — Nothing but the opposition which plants encounter from overcrowding or from the attacks of their enemies prevents any hardy kind of plant from covering all suitable portions of a whole continent, to the exclusion of most other vegetable life. New Zealand and the pampas of La Plata and Paraguay, in South America, have, during the present century, furnished wonderful examples of the spread of European species of plants over hundreds of thousands of square miles of territory. The newcomers were more vigorous, or in some way better adapted to get on in the world, than the native plants which they encountered, and so managed to crowd multitudes of the latter out of existence.

In our own country a noteworthy case of the kind has occurred so recently that it is of especial interest to American botanists. The so-called Russian thistle (Fig. 144), *Salsola Kali*, var. *tenuifolia*, a variety of the saltwort of the Atlantic coast, was first introduced into South Dakota in flaxseed brought from Russia and planted in 1873 or 1874. In twenty years from that time the plant had become one of the most formidable weeds known over an area of about twenty-five thousand square miles.

253. Importance of Adaptiveness in Plants. — It may be inferred from the preceding sections that a premium is set on all changes in structure or habits which may enable plants to resist their living enemies or to live amid partially adverse surroundings of soil or climate. It would take a volume to state, even in a very simple way, the conclusions which naturalists have drawn from this fact of a savage competition going on among living things, and it will be enough to say here that *the existing kinds of plants to a great degree owe their structure and habits to the operation of the struggle for existence*, this term including *the effort to respond to changes in the conditions by which they are surrounded.* How the struggle for existence has brought about such far-reaching results will be briefly indicated in the next section.

254. Survival of the Fittest. — When frost, drought, blights, or other agencies kill most of the plants in any portion of the country, it is often the case that many of the plants which escape do so because they can stand more hardship than the ones which die. In this way delicate individuals are weeded out and those which are more robust survive. One shellbark hickory bears nuts whose shell is easily cracked by hogs, while another protects its seeds by a shell so hard that it is cracked only by a pretty heavy blow. In case of all such differences, there is a strong tendency to have the less eatable fruit or seed preserved and allowed to grow, while the more eatable varieties will be destroyed. The result of this kind of advantage, in any of its countless forms, is sometimes called *survival of the fittest*, and sometimes *natural selection.* The latter name means only that the outcome of the process just described, as it goes on in nature, is much the same as that of the seed grower's selection, when, by picking out year by year the sweetest sugar-beets or the most nearly "stringless" beans, he obtains permanent new varieties. To obtain new species, though possible, would be more difficult, for these are divided from each other by greater differences than those which distinguish varieties from varieties (Sects. 256, 258). It has recently been proved by Professor Hugo de Vries, of Amsterdam, Holland, that while all plants, from generation to generation, show *variations*, sometimes they show *mutations* as well. A mutation is a sudden, marked change, a sort of leap, such as the growth of pecan trees from hickory nuts or of pansies from the seed of common blue violets would be. None of the observed mutations in plants have been as conspicuous as those above suggested, but to the botanist they are quite as remarkable. Since new species produced by mutation continue to reproduce themselves, many species may, in the course of ages, have been thus produced from a few ancestral forms.

CHAPTER XXII

THE CLASSIFICATION OF PLANTS[1]

255. Natural Groups of Plants. — One does not need to be a botanist in order to recognize the fact that plants naturally fall into groups which resemble each other pretty closely, that these groups may be combined into larger ones the members of which are somewhat alike, and so on. For example, all buttercups belong to the same division or *genus.*

The marsh marigold, the hepatica, the rue anemone, and the anemone all have a family resemblance to buttercups, and the various anemones by themselves form another group like that of the buttercups.

256. Genus and Species. — Such a group as that of the buttercups is called a *genus* (plural *genera*), while the various kinds of buttercups of which it is composed are called *species.* The scientific name of a plant is that of the genus followed by that of the species. The generic name begins with a capital, the specific does not unless it is derived from the name of a person or the name of a genus. After the name comes the abbreviation for the name of the botanist who is authority for it ; thus the common elder is *Sambucus canadensis* L., L. standing for Linnæus. Familiar examples of genera are the Violet genus, the Rose genus, the Oak

[1] See Warming-Möbius's *Handbuch der systematischen Botanik*, Borntræger, Berlin; Strasburger, Noll, Schenk, and Karsten's *Text-Book of Botany*, Part II, Macmillan, New York; or Engler's *Syllabus der Pflanzenfamilien*, Engelmann, Leipzig.

genus. The number of species in a genus varies widely, — the Kentucky Coffee-tree genus contains only one species, while the Golden-rod genus comprises more than forty species in the northeastern United States alone.

257. Hybrids. — If the pollen of a plant of one species is placed on the stigma of a plant of the same genus but a different species, no fertilization will usually occur. In a large number of cases, however, ovules will be fertilized and good seed be produced. This process is called *hybridization*, and any plant grown from such seed is a *hybrid*.[1] Many hybrid oaks and violets have been found to occur in a state of nature, and hybrid forms of wheat, orchids, grapes, and other cultivated plants are produced by plant breeders at will (Chapter XXIX).

258. Varieties. — Oftentimes it is desirable to describe and give names to subdivisions of species. All the cultivated kinds of apple are reckoned as belonging to one species, but it is convenient to designate such varieties as the Baldwin, the Bellflower, the Rambo, the Gravenstein, the Northern Spy, and so on.

259. Family. — Genera which resemble each other somewhat closely are classed together in one family. The particular genera mentioned in Sect. 255, together with a large number of others, combine to make up the Buttercup family. In determining the classification of plants most points of structure are important, but (in the case of seed-plants) the characteristics of the flower and fruit outrank others because they are more constant, since they vary less rapidly than the characteristics of roots, stems, and leaves do under changed conditions of soil, climate, or other surrounding circumstances. Mere size or habit of growth

[1] See L. H. Bailey's *Plant Breeding*, The Macmillan Company, New York.

has nothing to do with the matter, so the botanist finds no difficulty in recognizing the strawberry plant and the apple tree as members of the same family.

This family affords excellent illustrations of the meaning of the terms *genus*, *species*, and so on. The Rose family contains (among many others) the Pear genus, which contains the apple species, which contains the greening variety.

260. Grouping of Families. — Families are assembled into orders and these again into larger groups. The principal names of groups used in classification, beginning with the highest, are as follows:

Plant Kingdom.
Division.
Series.
Class.
Order.
Family.
Genus.
Species.
Variety.

The entire plant kingdom may be divided into four grand divisions and these into lesser groups, as shown in the table on page 210. *This table is for reference only.* It serves in a general way to represent the progress of plant development, beginning with the lowest (and oldest) types and proceeding to the highest. The algæ and fungi should, however, be placed parallel to each other and not in series, since the latter are distinguished from the former mainly by their parasitic or saphrophytic mode of life and the modifications due to this. No perfect scheme of classification has yet been made out and the highest authorities differ in regard to details of classification.

261. Outline of Classification.

DIVISION I. *Thallophyta*, thallus plants.

SERIES OF THE ALGÆ.

CLASS 1. *Cyanophyceæ*, blue-green algæ.
" 2. *Diatomaceæ*, diatoms.
" 3. *Conjugatæ*, conjugating algæ.
" 4. *Chlorophyceæ*, green algæ.
" 5. *Phæophyceæ*, brown algæ.
" 6. *Rhodophyceæ*, red algæ.

SERIES OF THE FUNGI.

CLASS 7. *Schizomycetes*, bacteria.
" 8. *Saccharomycetes*, yeasts.
" 9. *Phycomycetes*, algal fungi.
" 10. *Ascomycetes*, sac fungi.
" 11. *Basidiomycetes*, basidia fungi.

DIVISION II. *Bryophyta*, liverworts and mosses.

CLASS 1. *Hepaticæ*, liverworts.
" 2. *Musci*, mosses.

DIVISION III. *Pteridophyta*, ferns and their allies.

CLASS 1. *Filicineæ*, true ferns.
" 2. *Equisetineæ*, horsetails.
" 3. *Lycopodineæ*, club mosses.

DIVISION IV. *Spermatophyta*, seed-plants.

SUBDIVISION I. *Gymnospermæ*.

SUBDIVISION II. *Angiospermæ*.[1]

CLASS 1. *Monocotyledoneæ*, or Monocotyledons (divided into 11 orders).
" 2. *Dicotyledoneæ*, or Dicotyledons.

SUBCLASS 1. Choripetalous plants (divided into 28 orders).
SUBCLASS 2. Sympetalous plants (divided into 8 orders).

[1] Note that the angiosperms or non-coniferous seed-plants, making up the immense majority of what are ordinarily known as flowering plants, only comprise two out of the eighteen classes of plants here outlined. Many of the very lowest forms of life, which combine some of the characteristics of animals and plants, are omitted from this table.

CHAPTER XXIII

CHARACTERISTICS OF SPORE-PLANTS

262. Definition of a Spore-Plant. — A spore-plant is one which does not form seeds but is reproduced by means of a one-celled reproductive body called a *spore*.[1] Such bodies do not contain an embryo; they are of microscopic size and in all ways are far simpler than seeds.

263. Diversity among Spore-Plants. — Spore-plants are extremely diverse in their size, structure, and life habits, and in the details of their reproductive processes.

The simplest and smallest among them are one-celled organisms, not more than a fifty-thousandth of an inch in diameter, while the largest seaweeds are nearly or quite a thousand feet in length, and tree ferns reach a height of thirty or forty feet, with ample spreading crowns (Plate XI).

The pale or colorless spore-plants, such as bacteria, molds, and toadstools or mushrooms (Figs. 169, 172, 185), can live only as *parasites*, taking their food from living animals or plants, or as *saprophytes*, feeding on the products of decay.

The green spore-plants, however, carry on their nutritive processes as the higher plants do (Chapter XIII), and in all such relatively complex forms as the horsetails and

[1] Seed-plants (commonly called flowering plants) also produce spores (Sect. 383), but those forms which are treated in Chapters XXIII–XXVII may fairly be called spore-plants since the spore is their highest means of reproduction.

the ferns, the arrangements for respiration, photosynthesis (Sect. 163), and transpiration are very complete.

The student can obtain a reasonably thorough knowledge of the lower plants only by a prolonged study of many types. It is possible, however, to get some idea of their general appearance by a rapid examination of some characteristic forms.

264. Examination of Yeast. — Obtain some growing yeast-cells from compressed yeast mixed with molasses and water. Put a very small drop of the liquid on a slide, cover with a cover-glass, and examine with h.p. (high power).[1] Note the apparent size, shape, contents, and characteristics of the cells. Each cell is a yeast plant. Their actual diameter averages about one three-thousandth of an inch. Lacking chlorophyll they are incapable of making food by photosynthesis (Sect. 163) and live on the substances in which they cause fermentation.

265. Examination of Pleurococcus. — Collect some of the green coating which is usually found on the north sides of tree trunks or unpainted fences. Place a few flakes of bark or bits of wood with their green covering in a plate, moisten with water, cover with a bell-glass, and leave for two or three days in a warm, sunny place. Scrape off a minute portion of the green coating, mount in water, and examine, first with m.p. (medium power) and then with h.p. (high power). Note the single cells and grouped cells. Each cell is a *Pleurococcus* plant. The groups result from cell division, and the plant reproduces itself freely in this way. Make a careful drawing to show the shapes of isolated cells and of some groups. *Pleurococcus* contains abundant chlorophyll and produces plant food by photosynthesis.

266. Examination of Cladophora.[2] — Study living or preserved material in a little water in a white saucer by aid of a magnifying glass. Mount a very small portion in a drop of water on a slide, cover with a cover-glass, and examine with m.p. Note the shape of the filaments

[1] Throughout this and subsequent chapters the powers of the microscope will be referred to as l.p., m.p., and h.p., meaning respectively low power, medium power, and high power (see Appendix II).

[2] Any filamentous green alga such as *Zygnema*, *Mesocarpus*, *Stigeoclonium*, or *Draparnaldia* will answer. See Bergen and Davis' *Principles of Botany*, Chapter XX, Ginn & Company.

and whether or no they branch. Make a *habit sketch* to show all that you can of the general appearance of the plant. With the h.p. note the exact form and mode of connection of the cells of which the filaments are composed, and the size and shape of the chlorophyll bodies. In the group to which *Cladophora* belongs these are often band-shaped, star-shaped, or tabular and comparatively large. Make a careful drawing to show these points. Plants of this group are more complex than *Pleurococcus*; but their nutrition is not of a higher character.

267. Examination of a Moss-Plant. — Study any convenient leafy moss-plant (best in a fresh condition) with the magnifying glass. Note the root-like fibers, the stem, and leaves. How are the leaves arranged? Examine a leaf in water with m.p. and note whether it consists of one or more layers of cells. Describe the chlorophyll bodies. Examine the stem for woody fibers. State several respects in which the moss-plant seems more highly organized than any of the spore-plants discussed in Sects. 264–266. Its leaves are well adapted for photosynthesis.

268. Examination of a Fern.[1] — Note the division of the fern into underground portion (rootstock and roots) and aërial portion (leaves, with or without a stem). Describe the leaves and note how their veining differs from that of seed-plants. Look on the under surface of the leaves for spore-bearing regions, usually brown in color (Fig. 204). If any are found, describe exactly their location. Strip off a bit of the lower epidermis of a leaf, mount, and examine it with m.p. for stomata. Look for woody fibers in the stem. The fern is nearly as well equipped for photosynthesis and for transmission of water through the stem as are most seed-plants.

269. Summary. — The student has made a hasty examination of five types of spore-plants not including the very lowest nor the very highest. Discussion of their modes of reproduction has purposely been omitted, as the object of these simple studies has been merely to obtain some idea of the shape and structure of a few spore-plants in their vegetative condition.

[1] Any kind of terrestrial fern except the genus chosen for study in Sects. 362–364.

From the types discussed it is evident that in the case of yeast and *Pleurococcus* a cell is an individual plant. In *Cladophora* and many other thread-like genera either one cell of a filament or a straight or branching row of similar cells is an individual. In the mosses, ferns, and still more highly developed types the plant is composed of many layers of cells, which have assumed various forms to fit them for their several duties.

270. Series of Spore-Plants. — The spore-plants are grouped in three grand divisions, or *series*, as follows:[1]

SERIES I. *Thallophytes*.[2] One-celled or several to many-celled plants of very simple organization, usually without separate root, stem, and leaves, always without fibro-vascular bundles.

SERIES II. *Bryophytes*, or liverworts and mosses. Small plants which sometimes consist merely of a nearly flat mass of cellular tissue sometimes have a leafy stem, but are always without true roots or fibro-vascular bundles. The method of reproduction is of a far more advanced character than in Series I.

SERIES III. *Pteridophytes*, or ferns, horsetails, and club mosses. Plants, some of them small, others large, with true roots, stems, and leaves, and with fibro-vascular bundles (although the vessels have not exactly the structure of those in seed-plants). The method of reproduction is still more advanced than in Series II.

[1] See p. 210. This section should not be studied in detail until the discussion of pteridophytes (Chapter XXVII) is completed.

[2] This is a rather miscellaneous group and the name is somewhat misleading, as some bryophytes also have a plant body consisting only of a flat thallus.

CHAPTER XXIV

THE ALGÆ [1]

271. Definition; Occurrence. — *The algæ comprise all of the plants below the liverworts and mosses with the capacity for photosynthesis.* They constitute a series of the division *Thallophyta* (see Sect. 261).

Most algæ are aquatic, some inhabiting fresh and others salt water, but a few groups flourish in merely damp situations, such as on moist earth, bark, or wood. Still others (constituting the photosynthetic part of lichens) grow in partnership with certain fungi (Sect. 327).

272. Classes of Algæ. — Algæ are divided, mainly on the basis of their modes of reproduction, into six great groups, as follows:

CLASS 1. Blue-green algæ, *Cyanophyceæ.*
" 2. Diatoms, *Diatomaceæ.*
" 3. Conjugating algæ, *Conjugatæ.*
" 4. Green algæ, *Chlorophyceæ.*
" 5. Brown algæ, *Phæophyceæ.*
" 6. Red algæ, *Rhodophyceæ.*

The color, though not a basis of classification, forms a very convenient means of naming and roughly distinguishing some of the groups; it does not, however, serve to distinguish Class 3 from Class 4.

[1] See Bergen and Davis' *Principles of Botany* and Whipple's *Microscopy of Drinking Water*, Wiley & Sons, New York.

OSCILLATORIA, — ONE OF THE BLUE-GREEN ALGÆ

273. Occurrence. — *Oscillatoria* may occur floating in stagnant water, about watering troughs or outlets of drains and sewers, or on pots in greenhouses. In general it flourishes in the presence of dissolved and decaying organic matter.

274. Gross Structure. — Examine with the magnifying glass a bit taken from a growing mass of the plant and left for some hours in a white saucer with a little water. Note:

(*a*) The color.

(*b*) The filaments radiating from the rather compact mass of the plants.

275. Minute Structure. — With m.p. note:

(*a*) The shape of the filaments. Are they branched?

(*b*) Their movements. Describe these. Sketch several filaments.

With h.p. note:

(*c*) The shape of the tip of a filament.

(*d*) The coin-shaped cells of which the filaments are made up.

(*e*) The occasional occurrence of a dead cell, leaving a transparent place in the filament.

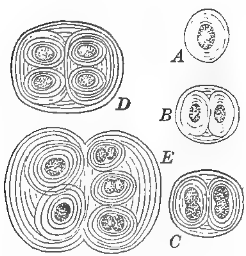


FIG. 150. *Glœocapsa*, one of the Lowest of the Blue-Green Algæ. (× 300.)

A-E, successive stages in the development of new individuals from a parent-cell.

(*f*) The delicate sheath inclosing the filament (best seen where a dead cell occurs). Make a careful drawing showing the points (*c*, *d*, *e*, *f*) above mentioned.

276. Discussion. — *Oscillatoria* is a plant of very low organization, marked, for example, by the absence of a well-defined nucleus in the unit cells of which the filaments are composed. Each cell is an individual plant, although, as the student has seen for himself, they live in communities. The flattened form of the cells is evidently due to the pressure exerted upon each by its neighbors, since at the tips of the filaments and on each side of a dead cell the unopposed pressure of the protoplasm causes the cell-walls to become convex (see Sect. 280).

Oscillatoria contains abundant coloring matter of a bright bluish green or steel blue. If a small quantity of dried *Oscillatoria* is pulverized and then soaked in water, the water is colored blue by the pigment which it extracts from the cell-contents. The residue may then be treated with alcohol, which becomes green from the chlorophyll dissolved from the *Oscillatoria*.

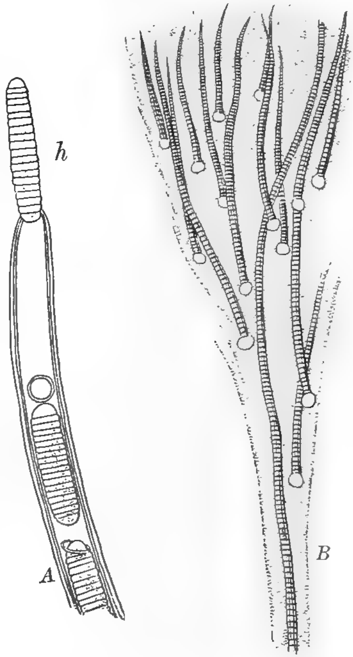


FIG. 151. Blue-Green Algæ.

A, a filament of *Calothrix*, reproducing by *hormogonia*, *h*, segmented portions which escape from the sheath of the filament; *B*, *Rivularia*. (Both *A* and *B* greatly magnified.)

Photosynthesis is carried on readily by this plant, as is evident from the oxygen bubbles which it gives off freely in sunlight.

Reproduction in *Oscillatoria* is usually performed by the breaking off of filaments at the places where dead cells occur. Each separated bit of filament continues to produce new cells by the formation of new partition walls (Fig. 152). The simple method of cell-division shown in the figure is not the usual one in higher plants. In the latter every cell commonly possesses a distinct nucleus, and this generally goes through complicated changes of form during the process of nuclear division (see Bergen and Davis' *Principles of Botany*, Sect. 199).

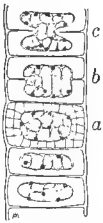


FIG. 152. *Oscillatoria.*

A few cells are shown treated with reagents to show the protoplasmic cell-contents more clearly. At *b* the cell-wall is sending a partition inward, and the protoplasmic contents beginning to divide. At *c* the division (*fission*) has proceeded still further. (Much magnified.)

277. Summary of the Blue-Green Algæ.—Many species of the blue-green algæ occur in fresh water, especially in warm waters which are impure from decaying organic matter, and in hot springs, some are found in sea water, a good many flourish on damp earth, and a few inhabit cavities in other plants.

The blue-green algæ are plants of very low organization. Some of them consist of single cells, living in a solitary way, others have the individual cells held together in masses by a gelatinous substance, and still others, like *Oscillatoria*, consist of thread-like rows of cells.

Blue-green algæ differ from other algæ in the nature of their coloring matter,[1] in the absence of well-defined nuclei in the cells, and in the simple mode of reproduction, by cell-division. From the readiness with which their cells split into new ones they are often called *fission algæ.*

[1] Their color is never exactly that of chlorophyll, but ranges from something not much unlike chlorophyll to blue-green, orange-yellow, brown, red, or violet.

SPIROGYRA,—ONE OF THE CONJUGATING ALGÆ

278. Occurrence. — *Spirogyra*, one of the commonest of the plants known as pond-scums, occurs widely distributed throughout the country in ponds, springs, and clear, slow streams. It is of a bright green color (yellowish green when producing spores). In warm sunny weather the masses usually float, buoyed up by the

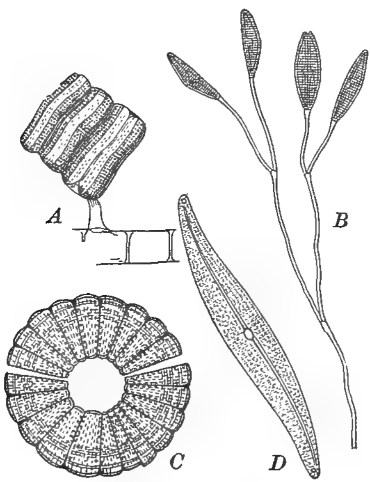


FIG. 153. A Group of Diatoms.

A, Achnanthes; B, Cocconema; C, Meridion; D, Pleurosigma.

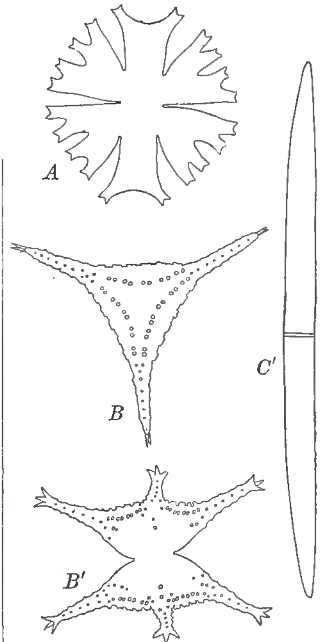


FIG. 154. A Group of Desmids.

A, Micrasterias; B, B′, Staurastrum (two views); *C, Closterium.*

numerous oxygen bubbles which the plants set free. It grows in unfrozen springs even in midwinter. Not infrequently several species are found growing with the filaments intermixed.

279. Gross Structure. — Gently rub between the finger and thumb a mass of filaments and note the feeling, unlike that of most filamentous algæ.

Tease out a few filaments in a very little water in a white saucer and examine with the magnifying glass. Note:

(*a*) The color of the threads.

(*b*) Their diameter.

(*c*) Their length, relative to their diameter. Do they branch?

280. Minute Structure. — Mount some bright green filaments in water under a large cover-glass, examine with m.p., and note:

(*a*) The form of the filaments, whether perfectly cylindrical or not.

(*b*) The division of each filament into many cells by transverse partitions. Make a drawing to show these points.

Examine with h.p. and note:

(*c*) The shape of a single cell.

(*d*) The thickness and form of the cell-walls, both at the exterior of the filament and in the partitions.

(*e*) The cell-contents including:

(1) Chlorophyll bands, or *chromatophores*. Count these.

(2) Pyrenoids, or starch centers.

(3) Clear cell-sap occupying most of the interior of the cell.

Take some *Spirogyra* which has been for a good many hours in bright sunlight. Mount a few filaments and slightly stain them by running in iodine solution at one edge of the cover-glass while water is withdrawn from the other edge by a bit of blotting paper. Examine with h.p. and note:

(*f*) The *pyrenoids*, small light-colored spots in the chlorophyll band, each surrounded by many dark-stained starch granules.

(*g*) The *nucleus*, a lens-shaped or ellipsoidal body, usually stained brown by the iodine, and often in a position near the center of the cell.

Mount a few filaments of *Spirogyra* in water under a small cover-glass, run in five-per-cent solution of common salt under one edge of the cover, and watch the filaments through m.p. The h.p. may later be substituted. Note the manner in which the living protoplasm of the cell, the *protoplast*, shrinks away from the cell-wall. The denser salt solution draws out water from the cell-sap at the interior of the protoplast and thus causes the latter to shrink. The process is called *plasmolysis.* It is an excellent illustration of osmosis and is easily demonstrated in many cells with thin walls and rather watery protoplasts.

281. Sexual Reproduction of Spirogyra. — Cut off with the dissecting scissors very small portions of material from the yellowish uneven filaments of *Spirogyra* which are often found clinging together.

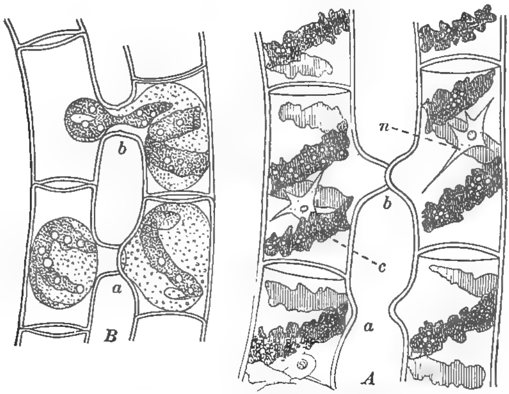


FIG. 155. Conjugating Filaments of *Spirogyra*. (Considerably magnified.)

A, beginning of the process; *B*, the same filaments in a more advanced stage of spore-formation. The cells at *a* in each portion of the figure are at an earlier stage of conjugation than those at *b*. *n*, nucleus; *c*, chloroplast.

Mount in a little water, without disturbing the relative position of the filaments, and examine first with m.p., then with h.p. Note:

(*a*) Filaments lying paired, as in Fig. 155, *B*, connected by *conjugating tubes.*

(*b*) Filaments in which the tubes have not been fully formed but appear only as projections (Fig. 155, *A*, *a*).

(*c*) The formation of ellipsoidal bodies, *zygospores*, by the union of the *protoplasts* of two conjugating cells.

(*d*) Intermediate stages between cells in their ordinary condition and cells containing a single zygospore or entirely emptied of their contents.

282. Discussion. — *Spirogyra* resembles *Oscillatoria* in consisting of filaments composed of a row of cells each of which is an individual plant. Its structure is, however, of a much higher character since the chlorophyll-containing material is in distinct bands, the pyrenoids form a special starch-making apparatus, and there is a well-defined nucleus. *Spirogyra* has a sexual as well as a non-sexual mode of reproduction, while in *Oscillatoria* the reproduction is always non-sexual.

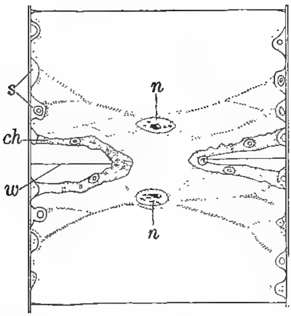


Fig. 156. Process of Non-Sexual Reproduction in a Species of *Spirogyra*. (× 230.)

At *n*, *n* the daughter nuclei are seen on either side of the newly forming partition wall *w*. By its growth the partition pushes inward the band of chlorophyll *ch* which lines the cell-wall. Sections of this band are seen at various points *s*. Threads of protoplasm join it to the nuclei.

Asexual reproduction, in *Spirogyra* as in *Oscillatoria*, consists of a process of cell-division, shown in Fig. 156. The nucleus divides into two daughter nuclei, and the protoplast becomes divided into two portions. A new partition-wall begins as a sort of ring, or diaphragm, and at length completely separates the two new nuclei. The process of cell-division in *Spirogyra* is much more complicated than in *Oscillatoria*, as in the former plant the nucleus goes through a remarkable series of changes (*mitosis*)[1] previous to the formation of the daughter nuclei shown in Fig. 156.

Sexual reproduction consists in the union of two apparently similar cells belonging usually to different filaments. A sexual cell which unites its contents with those of

[1] See Bergen and Davis' *Principles of Botany*, Sect. 199.

another cell in a reproductive process is called a *gamete*. If the gametes are similar, the resulting spore is called a *zygospore*. In the case of *Spirogyra* the zygospores are of service to the species by tiding over the winter season, or, in regions with a long, rainless summer, the dry season. In cool climates they are formed during the summer, but usually sink and remain long dormant, each throwing out a new filament and forming a new colony in the spring.

283. Summary of the Conjugating Algæ. — These algæ all occur in fresh or merely brackish water. Every cell has a nucleus. The *chlorophyll* is arranged in comparatively large protoplasmic bodies, which often take the form of spiral bands. The manner in which the zygospores are formed from the union of non-motile cells in *Spirogyra* is characteristic of the conjugating algæ.

One family, that of the desmids (Fig. 154), is in some respects similar to the preceding class (the diatoms, Fig. 153). *Spirogyra* and some other thread-like genera of the conjugating algæ much resemble the next class (the green algæ), though not the one shown in Fig. 157.

ŒDOGONIUM, ONE OF THE GREEN ALGÆ

284. Occurrence. — *Œdogonium* is found in pools, quiet ponds, horse-troughs, or slow streams of water throughout the year. This filamentous alga grows attached to stones, dead leaves, or other submerged objects.

285. Gross Structure.[1] — Examine with the magnifying glass a small amount of the material in a little water, and note:

(*a*) Whether the filaments are simple or branched.

(*b*) Whether they are long or short.

(*c*) Differences between the base and tip.

[1] See Bergen and Davis' *Principles of Botany*, Sect. 220.

286. Minute Structure. — Make a drawing of one or more filaments as seen with l.p. Draw the basal and the apical cell as seen with h.p. Under h.p. draw one of the cells near the middle of a filament and note:

(*a*) The large chromatophore, which almost fills the cell.

(*b*) The nucleus (if it can be seen).

(*c*) Pyrenoids. Test with iodine to see whether starch is present.

287. Reproduction.

I. Asexual

With h.p. look for cells in any of the filaments in which the protoplasmic body of the cell has changed into a pear-shaped cell (*zoöspore*) furnished at the smaller end with a fringe of *cilia*, or bristle-shaped appendages. Look also for the pear-shaped zoöspores swimming freely about by means of their cilia. Study their movements, then run in iodine under one edge of the cover-glass, to kill the cells, and note the form and structure of the zoöspore. Draw. If any germinating zoöspores can be found, draw them.

II. Sexual

With h.p. look for filaments which have large swollen cells at intervals along their length. Such a cell is called an *oögonium* and contains one *female gamete*, or *egg*. Note:

(*a*) The general form of the oögonium. Draw.

(*b*) The pore or opening to allow of fertilization.

(*c*) The egg-cell which nearly fills the oögonium.

Look for *antheridia*, groups of rather flat, tabular cells occurring near oögonia. These produce ciliated *sperms*, which enter the egg-cells and fertilize them. Draw a group of the disk-shaped cells.

Look for fertilized egg-cells, which may be distinguished by their heavy cell-walls. This fertilized cell is an *oöspore*. In the oöspores seen note:

(*a*) The dense cell-contents, due to the accumulation of food material. Test with iodine solution for starch.

(*b*) In the older oöspores the division of the contents into ciliated zoöspores, each of which may grow into a new filament of *Œdogonium*. Draw oöspores at various stages.

288. Discussion. — *Œdogonium* is a plant of decidedly higher type than *Spirogyra*. While the nutrition of both plants is much alike, *Œdogonium* shows a decided advance over *Spirogyra* in the structure of the vegetative filaments, inasmuch as these are not alike at both ends, but have a definite cell which serves as a holdfast and a terminal cell different from the others of the filament.

The sexual reproduction of *Œdogonium* is accomplished by the union of unlike gametes (sperm and egg-cell) and is therefore higher in type than that of *Spirogyra* in which the gametes appear to be alike. The small size of the sperms enables them to accomplish the fertilization of the egg with the expenditure of only a trifling amount of material, and the motility of the sperms enables them to reach the egg quickly, instead of drifting against it as one filament of *Spirogyra* drifts against another. Economy and certainty in the process of sexual reproduction are features of the progress of plants from lower to higher forms.

In some species of *Œdogonium* the antheridia are produced on small short filaments called *dwarf males*. These are developed from zoöspores which attach themselves to the female filament or to the oögonium.

VAUCHERIA, ONE OF THE GREEN ALGÆ

289. Occurrence. — *Vaucheria*, or green felt, is one of the rather widely distributed green algæ, some species being found in salt water and others in stagnant fresh water, sometimes in fresh running water or on damp soil. *V. sessilis*, the commonest species, occurs covering the earth of pots in greenhouses. When growing on earth it is rather easily recognized by its dark green color and the felt-like masses which it forms. It must not be confused with moss protonema (Fig. 199) which also grows on damp earth. The protonema has many cross-partitions in the filaments (often oblique in position) and lacks other

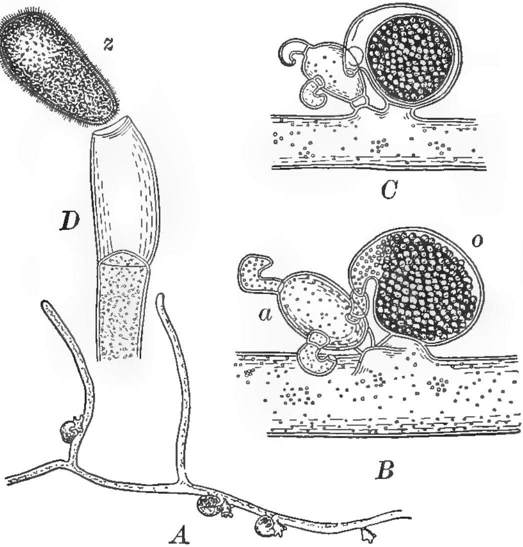


Fig. 157. *Vaucheria synandra.*

A, a filament with archegonia and antheridia (considerably magnified); *B*, part of same much more highly magnified; *o*, oögonium; *a*, antheridium; *C*, a later stage of *B*; *D*, end of a filament with a zoöspore, *z*, escaping (highly magnified).

characteristics shown in Fig. 157, *A*. It will also usually be found to be developing young moss plants.

290. Gross Structure. — Place in a white saucer or a watch glass with very little water some bits of earth on which *Vaucheria* is growing. Have other specimens growing in water in a sunny place, where they should have remained undisturbed for a week or more, covered with a bell-glass. Examine specimens on earth and in water with a magnifying glass and note:

(*a*) The general appearance of the felted mass of plants.

(*b*) The position of the growing filaments with reference to light. This is to be looked for only in specimens left long undisturbed in a good light.

(*c*) The mode of branching.

(*d*) The rhizoids or root-like extensions of filaments into the earth. These are best shown by washing away the earth with a carefully managed stream of water from a wash bottle.

291. Minute Structure. — Mount in water some filaments that have grown many days in water, examine with m.p., then with h.p., and note:

(*a*) Their varying diameter and the details of the branching.

(*b*) The presence or absence of cross-partitions.

(*c*) The form and size of the chlorophyll bodies.

If stained preparations mounted in balsam are available, study them with h.p. and note:

(*d*) The very numerous nuclei. Make drawings to show the points (*a*), (*b*), and (*c*).

292. Reproduction.

I. Asexual

With m.p. examine plants that have been growing in water in a sunny place for a week or more.[1] Look for:

(*a*) The formation of transverse partitions near the tips of branches. The end of the branch thus becomes a spore-case.

(*b*) The formation in each spore-case of a roundish, ciliated *compound zoöspore.*

(*c*) Zoöspores escaping or swimming about among the filaments.

(*d*) Zoöspores beginning to grow into new plants.

II. Sexual

In the same kind of material studied in I, look for paired, unlike organs occurring on the sides of some filaments (Fig. 157, *B*, *C*). Note:

(*a*) The shape, size, and structure of the smaller organ. It is an *antheridium*, producing very minute, ciliated *sperms.*

[1] For culture directions to secure fruiting *Vaucheria* and zoöspores see Bergen and Davis' *Field and Laboratory Manual*, pp. 95, 211, 212.

(*b*) The shape and size of the larger organ. It is an *oögonium*, containing many nuclei. Within the oögonium is developed an egg, which after fertilization becomes an *oöspore*.

(*c*) The shape, size, and thick cell-walls of the mature oöspores.

293. Discussion. — *Vaucheria* differs greatly from *Spirogyra* and from most of the green algæ. The filaments are not composed of separate cells, but the long branching tube is a complex cell with many nuclei. The spore-cases of the zoöspores, the antheridia, and the archegonia are of course additional cells or cell groups growing from the filament.

The process of sexual reproduction in *Vaucheria* consists of the union of the protoplasm of a sperm with that of an egg. This union is quickly followed by the development of a heavy cell-wall about the fertilized egg. The oöspore thus formed can resist unfavorable conditions much longer than the mature plants could do so. After a resting period the spore germinates and produces a new individual.

Vaucheria belongs to a considerably higher stage of development in the plant world than *Spirogyra* does. This is shown especially by two important points of difference.[1]

1. *Vaucheria* has one kind of cell for doing the vegetative work of the plant (photosynthesis, etc.) and other kinds for reproduction. In *Spirogyra* all the cells appear alike.

2. In *Vaucheria* the gametes are unlike. The sperms and the eggs are not only very unequal in size, but they differ much in structure and in power of movement, the sperms being freely motile while the eggs are stationary. In *Spirogyra* any gamete appears to be like all the others.

[1] These have already been stated in Sect. 288, but as *Œdogonium* is more likely to be omitted from a brief course than *Vaucheria* it seems best to repeat the statement.

Specialization of the apparatus for reproduction and differentiation of gametes are always found to accompany progress from the lower to the higher stages of plant development.

294. Summary of the Green Algæ. — Green algæ occur almost all over the earth's surface. They reach their highest development in fresh water, but there are many marine genera and species, and one of the most conspicuous of all the groups is that which embraces the sea-lettuce (*Ulva*) and its allies.

FIG. 158. End of a Main Shoot of a Stonewort, *Chara*. (About natural size.)

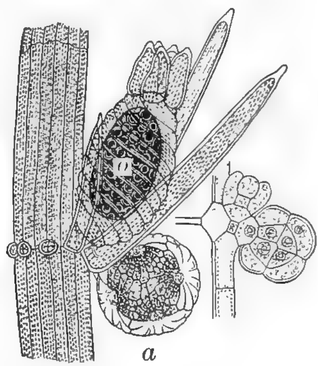


FIG. 159. Part of a "Leaf" of Fig. 158. (Considerably magnified.)

a, antheridium; *o*, oögonium. At the right are a young antheridium and archegonium.

This plant is a familiar object, waving as it does from rocks, piles, and wharves alongshore. Terrestrial genera and species of green algæ are not uncommon.

Under the class green algæ are grouped plants of many degrees of complexity in their organization and mode of reproduction. Complex cells like that of *Vaucheria* are not uncommon, and other genera have cell colonies of net-like form or take on thread-like shapes, like *Œdogonium*, or leaf-like or disk-like shapes, like the sea-lettuce or like *Coleochæte* (Fig. 220).

Highest in structure of all the green algæ are the stoneworts (Figs. 158, 159).

In green algæ the chlorophyll is not disguised by the presence of other coloring material. Reproduction is of many kinds, — often, as in *Pleurococcus*, wholly asexual, sometimes sexual, by the fusion of like gametes, and sometimes, as in *Œdogonium* and *Vaucheria*, sexual by the fusion of unlike gametes.

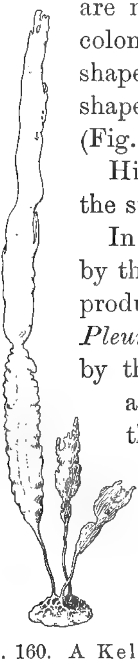


Fig. 160. A Kelp (*Laminaria*), one of the Brown Algæ. (Much reduced.)

FUCUS, ONE OF THE BROWN ALGÆ

295. Occurrence. — *Fucus vesiculosus*, or bladder wrack, one of the commonest of the so-called rockweeds, is found growing usually on rocks between high- and low-water marks, along the northern coasts of both hemispheres. It is often very luxuriant, completely covering the surface of the rocks to which it clings; and is extremely tough, resisting the most violent beating of the waves. It is easily recognized by the ribbon-like form (Fig. 161) with frequent branching and the numerous air-bladders which buoy it up in the water.

296. Gross Structure. — Examine some fresh or preserved material and note:

(*a*) The size, shape, and texture of single plants, the mode of branching, and the slimy coating of the entire plant.

(*b*) The location of the *air-bladders*.

(*c*) The mode in which the plant is attached to the rock by an expanded *holdfast*.

(*d*) The enlarged fruiting tips, or *receptacles*, of some branches. Draw. The growing point is in a pit at the tip of each branch.

297. Reproduction. — Study the receptacles of different plants, cutting some of them across, and note that there are two kinds, differing in shape and in the external color and color of the contents. With a two-inch objective or a magnifying glass sketch a cross-section of each kind of receptacle showing the distribution of the *conceptacles* (Fig. 164), each opening by a pore to discharge its contents.

Pick out with the point of a scalpel the contents of a conceptacle of each kind and examine with m.p. Note:

(*a*) The sterile hairs.

(*b*) The sac-shaped *antheridia* borne on branching hairs (Fig. 162).

(*c*) The nearly spherical *oögonia*, large cells from each of which eight eggs are developed.[1]

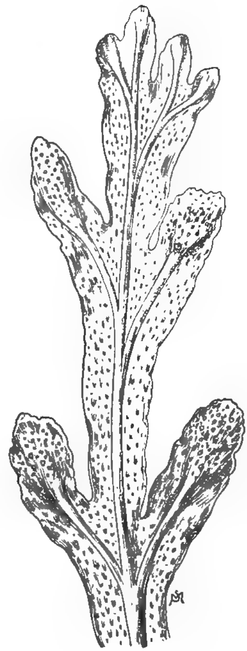


FIG. 161. Part of Thallus of a Rockweed (*Fucus platycarpus*). (Natural size.)

The two uppermost branchlets are fertile.

Observe that while the conceptacle shown in Fig. 164 contains both antheridia and oögonia, those of *Fucus vesiculosus* contain only one kind of sex organ.

[1] Prepared slides with stained sections of conceptacles may be studied to advantage.

298. Discussion. — *Fucus* is a much more highly developed plant than any of the blue-green or green algæ studied in the previous sections. It has a complete cellular structure and there is considerable division of labor among the different parts of the plant. It has a special holdfast, air-bladders to serve as floats,[1] a tough midrib running lengthwise of the branches and strengthening them, and expanded margins of the branches, affording ample surface for photosynthetic work. The outer layers of cells are especially devoted to photosynthesis and the inner ones to storage of food material. The brown cell-contents contained in *Fucus* and other brown algæ is highly efficient in photosynthesis.

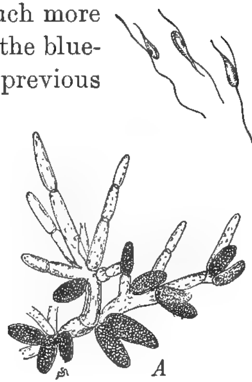


FIG. 162. Rockweed (*Fucus*)

A, antheridia borne on branching hairs (× 160); *B*, three sperms from the same (× 330).

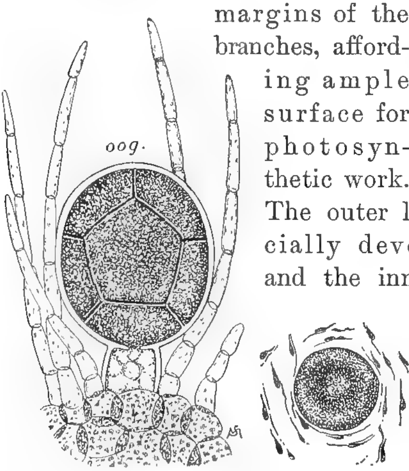


FIG. 163. Rockweed (*Fucus*).

A, oögonium, its contents dividing into eight oöspheres (× 160); *B*, an oösphere, escaped, surrounded by many sperms (× 160).

There is no asexual process of reproduction in *Fucus*. Sexual reproduction is accomplished by the eggs and sperms becoming forced out

[1] These are absent in some species (Fig. 161).

of the conceptacles when the plants which bear them become partially dry between tides. When the plants are again covered with sea-water, each egg becomes surrounded by actively swimming sperms which set the egg itself in motion (Fig. 163, *B*). The egg is soon fertilized, becomes an oöspore surrounded by a special cell-wall, germinates, and forms a new plant. The unlikeness of the male and female gametes of *Fucus* in form, size, and motile power is very great; tens of thousands of sperms would be needed to make up a bulk equal to that of a single egg.

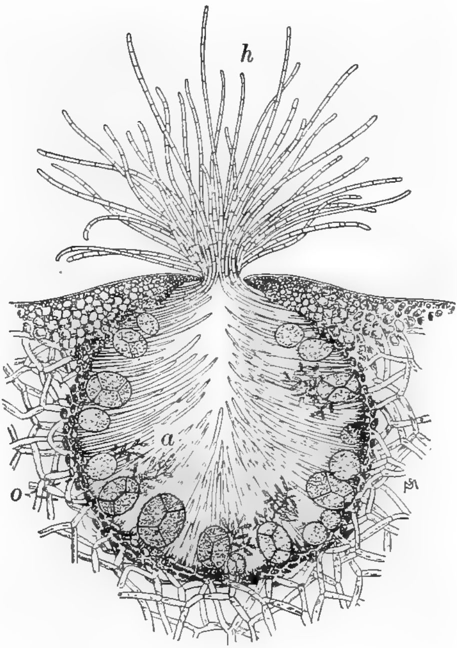


Fig. 164. Transverse Section of Conceptacle of a Rockweed (*Fucus platycarpus*). (× about 35.)

h, hairs; *a*, antheridia; *o*, oögonia.

299. Summary of the Brown Algæ. — The brown algæ are practically all of them marine, abounding most in the northern seas, and are usually known as seaweeds. They vary greatly in size, some being almost microscopic, while others, like the giant kelps of the Pacific, reach a length of from six hundred to nearly a thousand feet. The structure of some of the smaller forms is not very unlike that of the pond-scums (Sect. 278), while that of the larger ones, as the rockweeds, *Fucus* (Sects. 295, 296), and the kelps is rather complicated. The gulf-weed, *Sargassum*, related to the rockweeds, has expanded leaf-like branches for photosynthesis, globular air-bladders to float the plant, and small branches specialized for reproduction.

In the brown algæ the coloring matter appears yellowish brown or dark brown; by washing the plants in fresh water they soon become green, as the brown pigment is dissolved and removed. The reproduction is of various types, in the kelps wholly asexual, and in *Fucus* and its allies wholly sexual (Sect. 298).

RED ALGÆ[1]

300. Occurrence. — The red algæ are mostly marine and many of them are familiarly known as sea-mosses. They are especially abundant in the warmer seas, and some of them flourish in deeper waters than are frequented by the brown algæ.

301. Form and Structure. — Most of the red algæ are of moderate size, but some genera are minute, almost microscopic. The simplest forms consist of delicate branching threads, each composed of a single row of cells. Others, like the so-called Irish moss, appear as rather stout branching thalli, and others form broad wavy sheets. Some occur as incrustations on rocks or coral. The delicate feathery

[1] No laboratory studies on this group are given since the vegetative characters are not important for study in a brief course, and the sexual reproduction is too complicated to be mastered by beginners in botany.

kinds are the most beautiful of all the marine species. The colors of red algæ vary in different genera all the way from bright red to dark purple or reddish brown; one fresh-water genus, *Batrachospermum* (Figs. 165, 166), is often greenish.

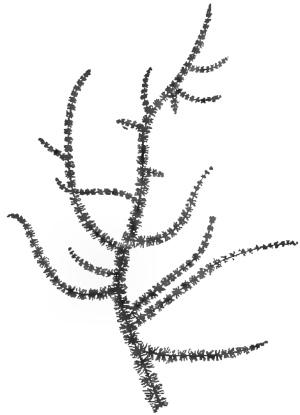


Fig. 165. *Batrachospermum*, a Red Alga. (Slightly magnified.)

302. Reproduction in Red Algæ. — Sexual reproduction among these algæ is highly complicated. It may be briefly described as due to the action of peculiar non-motile sperms upon the egg contained in a flask-shaped cell provided with a hair-like extension on which the sperms become lodged. Asexual reproduction is frequently accomplished by the formation of spores produced in fours and known as *tetraspores* (Fig. 168, *B*).

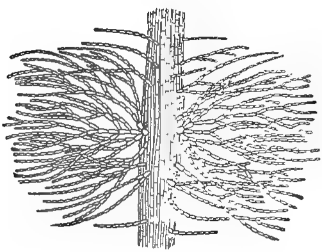


Fig. 166. Part of a Filament of *Batrachospermum*, not the species of Fig. 165. (Highly magnified.)

303. Additional Notes on the Algæ. — The algæ embrace so many types of plant life, including in all at least twelve thousand species, that it is not easy to make general statements which will apply to all the groups. The number of species may be more easily understood when it is mentioned that a single genus of diatoms contains some nine hundred species, and a genus of desmids three hundred. The number of individuals is inconceivably great. For example, there are in various

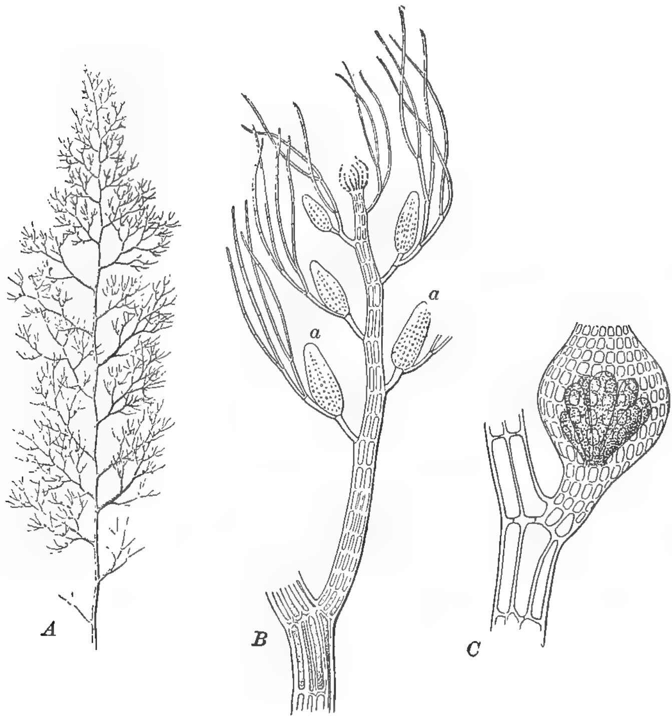


FIG. 167. *Polysiphonia*, a Red Alga.

A, a considerable portion of a female plant about natural size; *B*, a small bit of a male plant much magnified, showing the *antheridia*, or sperm-producing organs, *a*; *C*, a minute portion of a female plant (*A*), showing clustered *carpospores* enclosed in an urn-shaped envelope.

parts of the United States, in Africa, in Bohemia, and elsewhere extensive beds of siliceous shells or cases of fossil diatoms, often from thirty to fifty feet thick, and sometimes many miles in extent. It has been estimated that the diatomaceous earth of the Bohemian deposits contains forty-one million diatoms in every cubic inch. Similar deposits are to-day being formed in swamps, in lake-beds, and over large areas of sea-bottom.

The conditions of life under which algæ can exist are extremely various. One unicellular species, the red snow plant, *Sphærella nivalis*, gives a pink color to many square miles of snow in the arctic regions. Some of the blue-green algæ, on the other hand, live in hot springs at a temperature of 145° Fahrenheit. It is usually stated that algæ differ from fungi in being self-supporting, but at least one parasitic species is known.

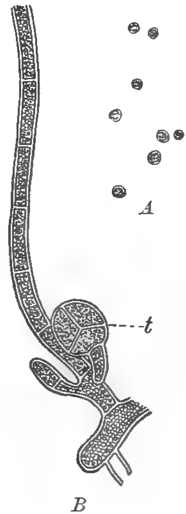


FIG. 168. Red Algæ.

A, spores of *Nemalion* (greatly magnified); *B*, portion of thallus of a red alga. *Lejolisia*, with tetraspores, *t*.

The green algæ have a special interest for the scientific botanist from the fact that they are supposed to be the ancestors of the mosses.

Few algæ have much direct economic value as articles of human food or as sources of manufactured products. Some, as the "Irish moss," the dulse, and "Ceylon moss," are eaten. Rockweeds are considerably used as fertilizers. Diatomaceous earth is sold under various names for polishing silver and other metals. Algæ, particularly of some minute floating marine groups, are of the greatest importance as food for shellfish and for many of the small organisms which form the diet of fishes.

The occurrence of blue-green and green algæ in city water-supplies is often a matter of serious importance, as it may give rise to very disagreeable tastes and smells. Some of the odors have been described as the moldy, the fishy, the "pig-pen" odor, and so on. Various means have been adopted for getting rid of the organisms, and most of them (including some animalcules) may readily be destroyed by adding a small proportion of copper sulphate to the water in the reservoir.[1] A bag of the copper salt trailed behind a boat rowed about over the surface will readily supply the needed amount of sulphate. Some of the most objectionable organisms are killed by as small a proportion of copper sulphate as one pound to five or ten million pounds of water, and in such a dilute solution as this the salt is not capable of exerting any poisonous action upon the drinkers of the water.

[1] See Bergen and Davis' *Principles of Botany*, pp. 170, 171. See also Whipple's *Microscopy of Drinking Water*, Chapter IX, John Wiley & Sons, New York.

CHAPTER XXV

THE FUNGI

304. Definition; Occurrence. — *The fungi are parasitic or saprophytic spore-plants.* They constitute a series of the division *Thallophyta.* The difference between algæ and fungi is one of mode of life, not of structure or of reproductive methods; and it cannot be said that fungi as a whole are either higher or lower in the scheme of classification than algæ.

Fungi occur in all situations where they can find organic food on which to live. Some are terrestrial, others aquatic; some can support life in a variety of situations, others are confined to the interior or exterior of the body of a single kind of host.

305. Classes of Fungi. — In treating the fungi they will here be grouped under five classes as follows:[1]

CLASS 7. Bacteria, *Schizomycetes.*
" 8. Yeast fungi, *Saccharomycetes.*
" 9. Algal fungi, *Phycomycetes.*
" 10. Sac fungi, *Ascomycetes.*
" 11. Basidia fungi, *Basidiomycetes.*

The classification of this great group of spore-plants is based partly on the modes of reproduction, partly on other considerations, and is as yet far from being definitely settled. The life history of many is only partially known.

[1] See p. 210.

306. Occurrence. — Bacteria are to be found almost everywhere. Although their extremely small size makes them quite invisible without the microscope, they are present in unimaginable numbers in most of the air we breathe and much of the food that we eat and the water that we drink. The commoner kinds are saprophytic and are to be found on most kinds of fermenting or decaying organic matter. Parasitic bacteria of many species occur in the bodies of animals and plants.

307. Cultures of Bacteria. — It is much easier to observe some of the effects produced by the growth of bacteria than to study the individual organisms. These are so small that in order to make out the details of their structure one needs a more powerful microscope than is usually found in school laboratories.

Pure cultures of bacteria are commonly made in some preparation of gelatine in sterilized test-tubes. Boiled potatoes serve a good purpose for simple (but usually not pure) cultures.

Select a few small roundish potatoes with skins entire and boil in water for a sufficient time to cook them through. Cut them in halves with a knife well scalded, or *sterilized*, *i.e.*, freed from all living organisms, in a flame, and lay each, with cut surface up, on a saucer, covering each with a glass tumbler. The tumblers and saucers should be well scalded or kept in boiling water for half an hour and used without wiping. Sterilization may be improved by baking them in an oven for an hour.

308. Inoculation. — The culture media prepared as above may now be inoculated. Uncover them only when necessary and quickly replace the cover. Scrape a little material from the teeth, tongue, kitchen sink, floor of the house or schoolroom, or any other place you may desire to investigate. With the point of a knife blade or a needle sterilized in a flame, inoculate a particle of the material to be cultivated into the surface of one of the potatoes. Several cultures may be made in this way and one or more left uninoculated as checks. Another may be left uncovered in the air for half an hour. Others may be made with uncovered potatoes. Number each culture and keep a numbered record.

Keep watch of the cultures, looking at them daily or oftener. As soon as any change is noticed on the surface of a culture, make a descriptive note of it and continue to record the changes which are seen. Note the color of the areas of growth, their size, outline, elevation above the surface, and any indications of wateriness. Any growth showing peculiar colors or other character of special interest may be inoculated into freshly prepared culture media, using any additional precautions that are practicable to guard against contamination.

309. Microscopic Examination. — Examine with h.p. some of the cultures. Place a particle of the growth on a slide, dilute it with a drop of clear water, and place a cover-glass over it. Note the forms and movements, also the sizes if practicable, of any bacteria that are found. Examine also scrapings from the surface of the teeth and look for various forms of bacteria.

310. Minute Structure. — Bacteria are spherical, rod-like, or spiral cells (Fig. 169). The cell-wall is thin and the protoplasmic contents usually colorless and apparently destitute of a nucleus. They are the smallest and among the simplest of known organisms. Extremely delicate *cilia* are often found, either at one extremity of the cell or distributed over its general surface. The movements of bacteria are due to the lashing motion of the cilia.

311. Life Habits of Bacteria. — As already stated (Sect. 306), bacteria are either saprophytic or parasitic. Species of the latter group can often be artificially induced to live as saprophytes.

Some kinds can only exist in the presence of free oxygen, while others cannot live in its presence. Those which require oxygen are more common and they flourish upon the surface of decaying animal and vegetable substances, causing them to putrefy. If meat, milk, eggs, or other perishable substances are sterilized by heating and then placed in sterilized vessels so arranged as to prevent any contact of the contents with air containing living bacteria, no putrefaction can occur. Canned goods may be kept unspoiled for an indefinite number of years, not because all the

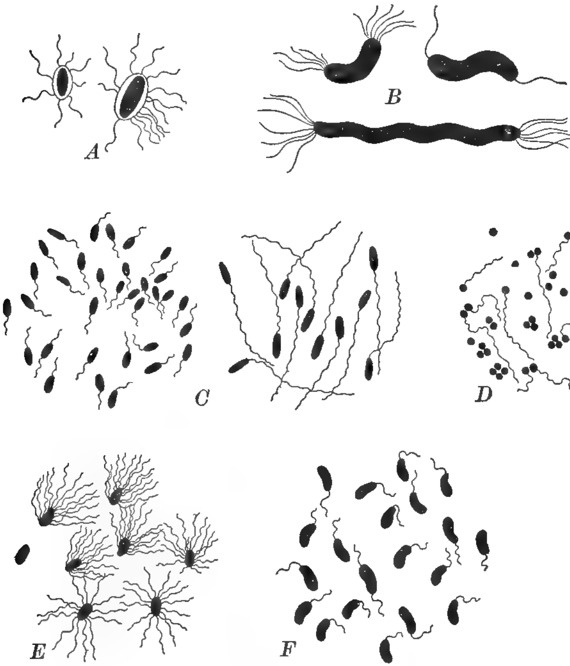


FIG. 169. Bacteria stained to show Cilia.

A, *Bacillus subtilis*, found in hay infusions; *B*, *Spirillum undula*, found in water containing decaying fish, algæ, etc.; *C*, species of *Pseudomonas*; *D*, *Planococcus citreus*, which forms yellow patches on various substances; *E*, *Bacillus typhi*, the cause of typhoid fever; *F*, *Microspira comma*, the cause of Asiatic cholera.

air has been driven out of the cans, but because they and everything in them has been sterilized by heat. Bacteria in the active growing condition cannot live if exposed for an hour to a temperature of 149°–160° Fahrenheit (65°–71° C.). The spores resist a much greater heat.

Light is unfavorable to the growth of bacteria in general, and this is one important reason why living rooms should be open to the sunshine.

Dryness will not immediately kill bacteria, but it stops their growth, and it is for this reason that evaporated fruits and vegetables keep without decaying. In the case of salted meats and fish, either smoked or not, the dryness and the presence of much salt prevent decay. Smoking adds some creosote which is an additional safeguard. Most bacteria cannot grow in the presence of much sugar or of vinegar, and this accounts for the keeping qualities of rich preserves and jellies as well as of pickles.

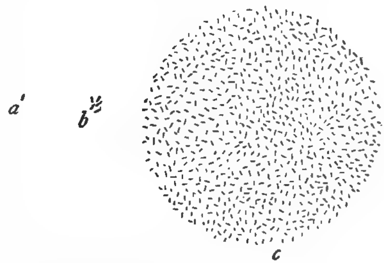


Fig. 170. Effect of Variations in Temperature on Bacteria Growth.

a, a single bacterium; *b*, its progeny in twenty-four hours at 50° Fahrenheit; *c*, its progeny in twenty-four hours at 70° Fahrenheit.

312. Reproduction.— Bacteria under ordinary circumstances reproduce by the division of the cells, each parent cell forming two new ones. From this fact they are often called *fission fungi*. Fission goes on much faster at rather high temperatures (Fig. 170). Resting spores are formed by many species. The process of spore formation consists of the interior portion of the protoplasm collecting into a minute ellipsoidal or globular mass which becomes surrounded by a thick membrane. The spores can survive high temperatures and extreme dryness, so that they are able to continue the life of the species on through very unfavorable conditions.

313. Economic Importance. — The great importance of the bacteria in relation to many of the affairs of everyday life has been suggested in several of the preceding sections. Farming, butter and cheese making, canning fruits and vegetables, and a variety of other manufacturing operations are largely dependent on employing certain useful bacteria or on warding off the attacks of injurious species.

Such important diseases as influenza, consumption, typhoid fever, diphtheria, cholera, and the plague are caused by the attacks of parasitic bacteria, and a most important division of medical science is occupied with the detection of these parasites and the means of destroying them.[1]

YEAST FUNGI

314. Occurrence. — Yeasts are microscopic one-celled plants which are very widely distributed in the air and in the soil. On account of their minute size their presence is generally recognized only by the effects which their growth produces. *Beer yeast* is used in bread making and in fermenting various gruel-like preparations of ground malt, rye meal, corn meal, and so on in the manufacture of beer and many distilled liquors. This species of yeast is only known in a cultivated condition, but there are many *wild yeasts* which cause the fermentation of grape juice, cider, and canned fruits.

315. Minute Structure and Reproduction. — The student can gather from Fig. 171 something of the structure of

[1] For general information about bacteria read Conn's *Bacteria, Yeasts, and Molds in the Home*, Ginn & Company.

the yeast-cell. It is spherical or ellipsoidal in shape, thin-walled, and contains nearly colorless protoplasm, which includes oily droplets known as *vacuoles* and a well-defined nucleus.

Multiplication ordinarily takes place by a process of *budding* by which the nucleus divides and a new cell is pushed out from the old one and finally cut off from it by a new cell-wall (Fig. 171).

Spore formation occurs when yeast is grown with scanty nourishment. The protoplasm breaks up into small, nearly spherical masses, often two or four in number, and these form spores which resist unfavorable conditions better than the ordinary yeast-cell.

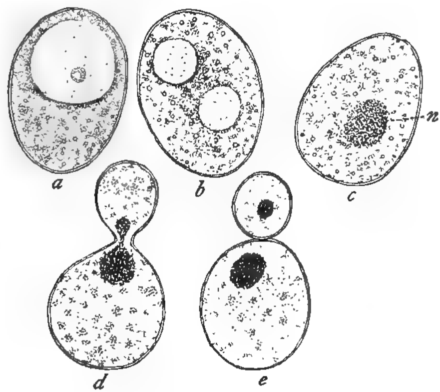


FIG. 171. Common Yeast very Highly Magnified.

a and *b* show vacuoles; *c* shows a nucleus *n* inside of the yeast-cell; *d* shows a budding cell with the nucleus dividing; *e* shows the cell divided, the new cell containing a bit of the old nucleus.

316. Alcoholic Fermentation. — The growth of yeast in a liquid which contains sugar destroys part or all of the sugar, changing it mostly into alcohol and carbon dioxide. The alcohol remains mixed with the liquid, while most of the carbon dioxide escapes in little bubbles.

In bread making the yeast grows at the expense of sugar in the dough (derived from the flour). The bread rises as the bubbles of gas escape, at the ordinary temperature, and becomes still lighter as the gas expands in the oven. Cakes of compressed yeast are nowadays generally used in bread making. It is important that they should be as fresh as possible, since when they are old they are likely to contain some wild yeasts and many bacteria. These are pretty sure to injure the quality of the bread made from such yeast.

RHIZOPUS, ONE OF THE ALGAL FUNGI

317. Occurrence. — The common bread-mold, *Rhizopus nigricans*, is found upon bread or cake left in a warm damp place, or on sweet potatoes, squashes, or bananas. Its spores are likely to be present in the dust of houses, and many lie dormant for months, producing when they alight on favorable food material a luxuriant crop of the downy coating of white silky threads so familiar to all.

318. Gross Structure. — Place some bread[1] in a soup plate, wet thoroughly, cover with a bell-glass, and leave for some days in a dark warm place, renewing the water if necessary. When a considerable growth of mold has appeared, examine with the magnifying glass an undisturbed portion as it grows from the surface of the bread. Note :

(*a*) The tangled network, or *mycelium*, visible on the surface of the bread (and really extending a good way down into it).

(*b*) The size and appearance of the separate threads, or *hyphæ*, of which the mycelium is composed.

(*c*) The presence of certain erect aërial hyphæ bearing minute globular *spore-cases* at their tips. Describe the color of the youngest spore-cases and that of the largest and oldest ones.

319. Minute Structure. — Wet a little of the mold with alcohol (to remove the air from it) and then mount in water and examine with m.p. Note :

(*a*) The mode of growth of the hyphæ, whether branched or unbranched.

[1] Gluten bread is particularly adapted for this culture.

(*b*) The root-like branches, or *rhizoids*, which proceed from some hyphæ into the bread or other substratum.

(*c*) The presence or absence of transverse partitions in the hyphæ.

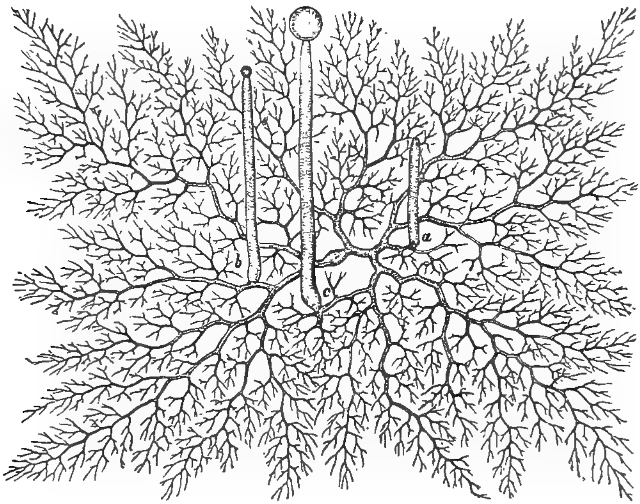


FIG. 172. Unicellular Mycelium of a Mold (*Mucor Mucedo*), sprung from a Single Spore.

a, *b*, and *c*, branches for the production of spore-cases, showing various stages of maturity. (Considerably magnified.)

(*d*) The granular protoplasm, more abundant in some parts of the hyphæ than in others.

Make one or more drawings to show the points above mentioned (*a–d*).

320. Reproduction. — With h.p. examine a series of spore-cases of various sizes and note:

(*a*) The various stages in the development of the spore-cases.

(*b*) The ripe spores escaping. Make a drawing to show these.

Sow some of the spores of (*b*) on the surface of "hay tea" made by boiling a handful of hay in just water enough to cover it and then straining through cloth or filtering through a paper filter.

After from three to six hours examine a drop from the surface of the liquid with m.p. After about twenty-four hours examine another portion of the mold from the surface of the liquid. Note:

(*c*) The beginning of formation of hyphæ and their continued development. Draw.

In a prepared slide study the conjugation of mold hyphæ and the formation of zygospores (Fig. 173).

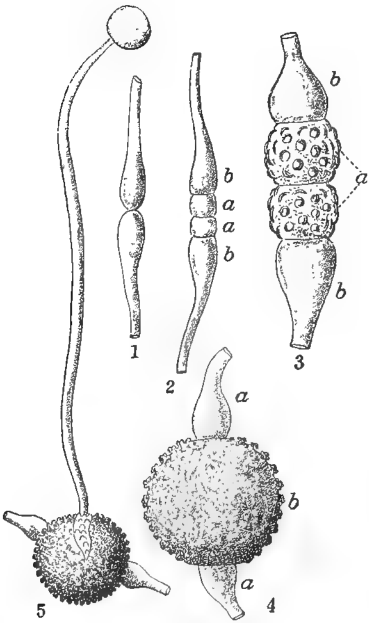


FIG. 173. Formation of Zygospores in a Mold (*Mucor Mucedo*).

1, threads in contact previous to conjugation; 2, cutting off of the conjugating cells *a* from the threads *b*; 3, a later stage of the process; 4, ripe zygospore; 5, germination of a zygospore and formation of a spore-case. (1–4 magnified 225 diameters; 5, magnified about 60 diameters.)

321. Discussion.—The bread-mold is a typical saprophytic fungus. In its structure, consisting of a much-branched and extremely large continuous protoplast with many nuclei, it considerably resembles *Vaucheria*. Its reproduction is of two kinds,—asexual, by the formation of spores within a spore-case, and sexual, by the conjugation of similar-appearing threads (gametes) forming zygospores. These (Fig. 173) are not as frequently produced by the bread-mold as by some other closely related genera.

The formation of the asexual spores in spore-cases is similar to the mode already mentioned in yeast fungi

(Sect. 315). The zygospore formation of bread-mold considerably resembles the mode of spore production in *Spirogyra* (Sect. 282), but the mold gametes contain many nuclei.

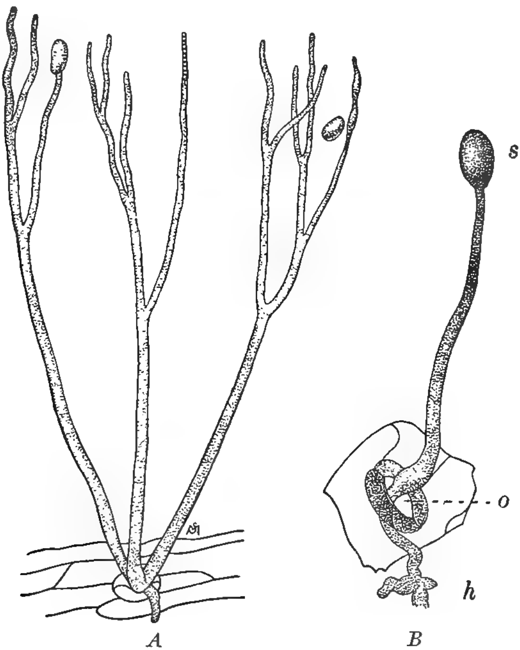


FIG. 174. Spore-Formation in Potato-Blight (*Phytophthora infestans*), one of the algal fungi.

A, a well-developed group of stalks, proceeding from a mass of mycelium inside the leaf and escaping through a stoma; *B*, a young, unbranched stalk. *h*, hyphæ of mycelium; *o*, stoma; *s*, spore. (Both figures greatly magnified, *B* more than *A*.)

It appears highly probable that such algal fungi as *Rhizopus* are degenerate descendants of green algæ more or less resembling *Vaucheria*.

MICROSPHÆRA, A SAC FUNGUS

322. Occurrence. — Species of the lilac mildew, *Microsphæra Alni* and allied forms, occur during the summer and autumn on leaves of various herbaceous and woody plants. The growth is confined to the surface of the leaf. Among the commonest species are those which grow upon lilac, oak, grape, cherry, willow, and wild plants of the Composite family. Some species are known to occur on only one host-plant, others on several, and the hosts may belong to more than one family. Besides *Microsphæra* there are about five other genera. All these fungi, from the appearance which they present in their earlier stages, are called powdery mildews.

323. Gross Structure.[1] — Examine with the magnifying glass the upper surface of a lilac leaf infected with *M. Alni*. Note:

(*a*) The color and distribution of the fungus on the upper surface of the leaf.

(*b*) The powdery or moldy appearance of the leaves first gathered, due to the abundant *conidia* (or conidiospores).

(*c*) The yellow or black dots on late-gathered leaves, *sac fruits*.

324. Minute Structure.[2] —

I. The Mycelium.

Examine with h.p. some scrapings or thin sections parallel to the leaf surface, or fungus spots from a leaf gathered early in the summer. Dried leaves may be moistened with five-per-cent solution of

[1] Material for all the studies of this *Microsphæra* should be gathered at three periods, — when the lilac leaves first begin to appear powdery (in June or July), then in early September, and finally just before the fall of the leaves. They should be pressed between sheets of porous paper.

[2] If the teacher prefers to use material which will show larger sac fruits he may use fresh or dried fructifications of the morel (Fig. 176). Dried morels must be soaked in warm water before sectioning. The sections should be cut perpendicular to the surface of one of the hollows of the morel.

potassium hydrate some time before they are to be examined. In the mycelial threads note:

(*a*) The color (if any).

(*b*) The mode of branching.

(*c*) The presence or absence of cross-partitions. Draw.

II. Conidia.

Examine with h.p. a slide prepared as in I, and note:

(*a*) The size, shape, and color of the conidia.

(*b*) The manner in which the conidia-bearing branches are attached to the mycelial threads and the way in which the conidia are cut off at the ends of these branches by cross-partitions.[1] Draw.

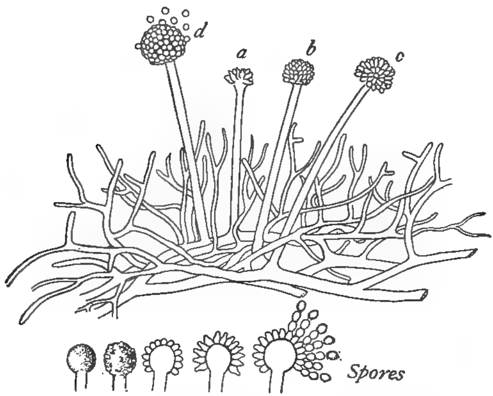


Fig. 175. A Colony of *Aspergillus*, a Sac Fungus, one of the Common Molds, showing Mycelium and Spore-Clusters. The lower figures show in detail the method of spore formation.

III. The Sac Fruits.

Prepare slides from the material gathered at the end of summer and at the fall of the leaf. Examine the yellowish or black sac fruits with h.p. and note:

(*a*) The shape of the fruits.

[1] It may be easier to demonstrate rows of conidia in "blue mold" (*Penicillium*) moistened in alcohol and then mounted in water.

(*b*) The surface markings.

(*c*) The number, shape, and mode of branching of the appendages. Draw a sac fruit showing the points above mentioned ($a - c$).

IV. THE SPORE-SACS AND SPORES.

Mount in water a few sac fruits under a very small cover-glass and press the latter strongly against the slide with a scalpel handle or the square end of a lead pencil until some sac fruits are crushed. Examine with h.p. and note:

(*a*) The spore-sacs (*asci*) escaping from the spore fruits.

(*b*) The *spores* contained in the spore-sacs. Make a drawing to show the asci escaping from the spore fruit, and the number, shape, and size of the spores within the ascus.

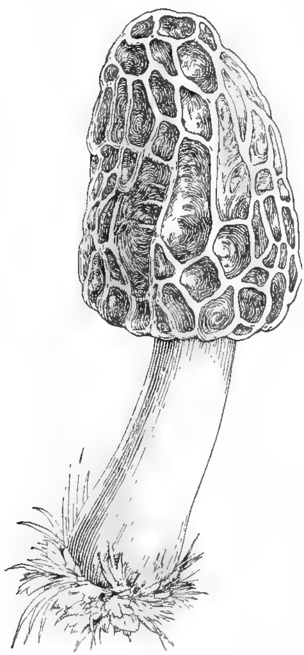


FIG. 176. The Morel (*Morchella esculenta*). (Natural size.)

325. Reproduction. — *Microsphæra* is reproduced in two ways. One method is asexual, by means of abundant aërial spores known as *conidia*, formed by the subdivision of special hyphæ into short segments, each of which may grow into a new plant. The other method is sexual, by the union of unequal gametes to form a sac fruit[1] (developed somewhat like that of the red algæ) which contains many spore-sacs.

326. Discussion. — The sac fungi are of interest to those who are not specialists in the study of this group, mainly

[1] In most sac fungi it is very difficult to find the gametes; therefore no laboratory work on them is here given.

on account of their economic importance. Forms differing enormously in general appearance, size, and life habits are included in this class.

Here belong two genera of large, edible fungi, the morel (Figs. 176, 177) and the truffle. Many injurious genera are found, some of them saprophytes and others parasites. Best known among the former are the green and the yellow molds, more properly called mildews (Fig. 175). A few examples of the latter are the grapevine mildew, the black-knot fungus of plum and cherry trees, the peach-curl fungus, the bitter rot of apples, the brown rot of peaches, and the plum pocket fungus.

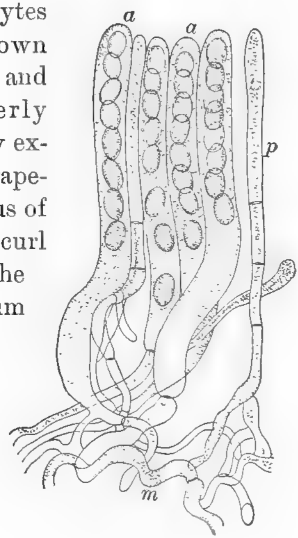


FIG. 177. A Vertical Section of the Spore-Bearing Surface of Fig. 176. (× 240.)

a, *asci*, or spore-sacs; *m*, mycelium; *p*, *paraphyses*, or sterile filaments.

LICHENS, SAC FUNGI AS MESSMATES WITH ALGÆ

327. Definition, Occurrence. — Lichens (Figs. 178, 179) were formerly supposed to be a distinct class of plants, and it is less than forty years since their real nature began to be understood. *A lichen is a combination of two plants.* The green cells, called the *gonidia* (Fig. 180, *g*), belong to some species of alga, and the remainder, the larger portion of the growth, is a fungus (usually a sac fungus) parasitic upon that alga. The groups of lichens correspond in structure to certain groups of fungi, but the genera are sufficiently distinct so that lichens are best considered by themselves for purposes of study and classification.

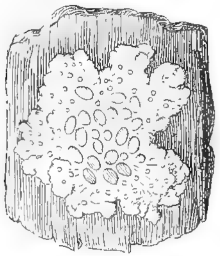


FIG. 178. A Lichen (*Xanthoria*). (Natural size.)

The relation of the fungus and its algal host is not that of destructive parasitism, but rather a mutual relation (*symbiosis*) in which both fungus and alga may have a vigorous growth. The relationship has been investigated in various ways, and it has been found that, while the alga may thrive independent of the fungus, the germinating fungus spores can grow only to a limited extent if deprived of the algal host; but if supplied naturally or artificially with the proper alga they make a normal growth. The same alga may serve as gonidia to a number of lichens, often of very different form, and while the number of lichens reaches into the thousands, the number of algæ known to serve as gonidia is quite small.

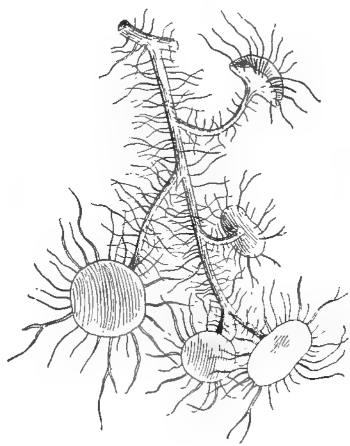


FIG. 179. A Lichen (*Usnea*). (Natural size.)

Lichens are widely distributed in all zones but flourish particularly in northern regions where other vegetation is scanty. Some were formerly important as sources of dyes. "Iceland moss" is a lichen used for food, and a finely branching form, growing in extensive mats on the soil, serves as food for the reindeer and is known as "reindeer moss."

Most lichens grow on the bark of trees, on rocks, or soil where they have little moisture except during rainfall, but some grow where they are constantly wet. Some of the latter are gelatinous. Most of the conspicuous lichens are foliaceous or else have a thallus composed of branching, cylindrical, thread-like portions. But many species, often less conspicuous, are crustaceous, growing as if they formed part of the bark or rock to which they are attached.

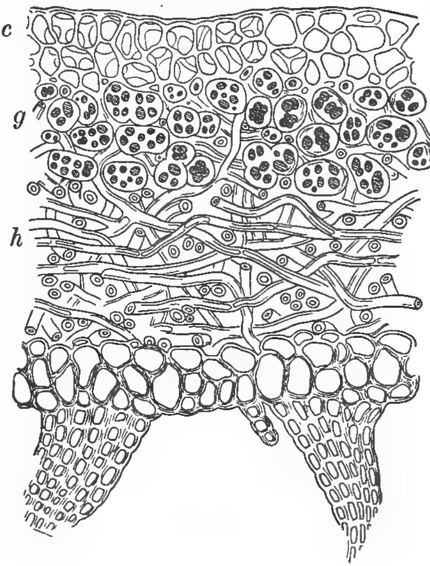


FIG. 180. Transverse Section through Thallus of a Lichen (*Sticta fuliginosa*). (× 500.)

c, cortical or epidermal layer; *g*, gonidia; *h*, hyphæ.

PUCCINIA, ONE OF THE BASIDIA FUNGI

328. Occurrence. — *Puccinia graminis*, wheat rust, is common on cultivated wheat and other grains and also on many wild and cultivated grasses besides the grains. Numerous species of rust are known. A rust may have one, two, or three kinds of spores, and when three occur one is known as the *cluster-cup stage* and the others as *red rust* and *black rust*, according to the usual approximate color of the spores. The rust called *Puccinia graminis*, growing on wheat, has its cluster-cup stage on the leaves of barberry in June. The spores from the cluster-cups are carried by the wind to the wheat, where they germinate and in a few days produce the red rust. A little later the black spores appear, produced by the same mycelium. This growth is chiefly upon the stems and sheaths.

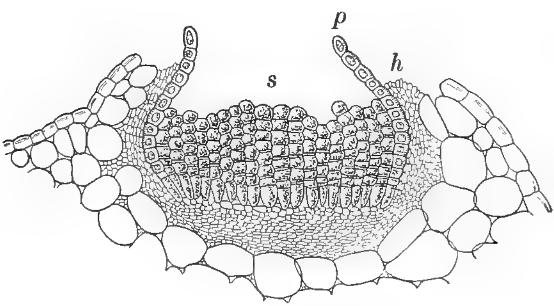


FIG. 181. A Cluster-Cup of Anemone Rust (*Puccinia fusca*). (× 120.)
s, chains of spores; *p*, the covering or *peridium* of the cup; *h*, hyphæ.

329. Cluster-Cup Stage, Gross Structure. — Procure if possible fresh specimens of infected barberry leaves. If these are not available, dried leaves soaked for a short time in water or (still better) leaves preserved in alcohol may be used. With the magnifying glass note:

(*a*) The occurrence of the cups (*æcidia*; singular *æcidium*). Are they on the upper or lower surface of the leaf?

(*b*) The number of cups in a cluster.

(*c*) The form, size, and color of the cups.

330. Cluster-Cup Stage, Minute Structure. — Cut a thin section of a leaf through a cluster of cups. This can best be done by holding the portion of leaf to be sectioned between two pieces of elder pith.[1]

[1] If desired, prepared slides can be bought of the dealers.

Examine first with m.p., and then with h.p. Note:

(*a*) The forms of the cluster-cups at various stages of growth. Compare with the cup on an anemone leaf, shown in Fig. 181.

(*b*) The structure of the cup, surrounded by a layer of mycelium, next to which comes the *peridium*, or wall of the cup. The latter is filled with chains of spores (*æcidiospores*). Draw the cup with its contents.

(*c*) The size and shape of the mature spores which separate from the ends of the chains.

(*d*) The cavities, smaller than the cluster cups and on the opposite surface of the leaf. These produce great numbers of minute cells which now apparently are of no service in the life of the fungus, though they may once have been.

331. Red-Rust Stage and Black-Rust Stage, Gross Structure. — Examine with the magnifying glass the surface of the leaf sheaths and stems of wheat or other grain or of quick grass (*Agropyrum repens*) collected in early summer and other specimens collected in autumn. Note the rust streaks extending lengthwise of the leaf sheaths and the stems. Describe the precise color of these streaks in the early- and the late-collected material. Draw some of the best defined streaks of each kind. In preserved material the early rust may have lost a good deal of its color.

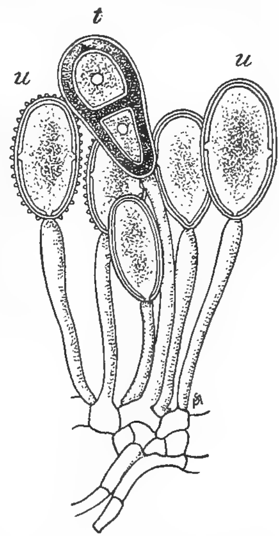


FIG. 182. A Group of Spores of Wheat Rust (*Puccinia graminis*). (× about 440.)

u, *u*, uredospores; *t*, a teleutospore.

332. Red Rust, Minute Structure. — Pick out with a scalpel or a knife point some spores (*uredospores*) from a streak of red rust. Tease the material out with dissecting needles in a drop of water on a slide.[1] Cover and examine with h.p. Note:

(*a*) The shape of the spores and the attachment of each to a stalk (Fig. 182).

[1] If the spores are dry, shrunken, and opaque they may first be soaked for a few minutes in a five-per-cent solution of potassium hydrate.

(*b*) The rough outer coating and the inner coating with (usually) four pits or thin places in its wall about midway of the spore.

333. Black Rust, Minute Structure. — Remove a small mass of the black-rust spores (*teleutospores*), mount, and examine as described in Sect. 332. Note:

(*a*) The shape and attachment of the spores (Fig. 182).

(*b*) The structure of the spore (composed of two cells) and the thickness of the cell-wall. Look for thin places or *germinating pores* in the cell.

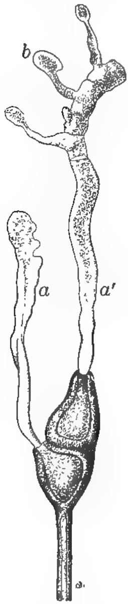


FIG. 183. A Germinating Teleutospore of *Puccinia graminis*.

a, *a′*, threads produced by the germination, from the ends of which grow short rows of cells which bear *basidiospores*, *b*. These are carried by the wind to the barberry host-plant.

334. Life History of Wheat Rust. —

This species of rust under favorable circumstances shifts from the barberry as a host-plant to wheat or other grass and back to the barberry again year after year. The cluster-cup spores are borne by the winds to grain or grass fields, where they germinate and develop red-rust streaks full of uredospores. These spores are carried to other wheat plants on which they germinate, and so the growth of the fungus spreads. In late summer or autumn the same mycelium which earlier produced uredospores forms only teleutospores and the red-rust streaks turn blackish. The teleutospores survive the winter and in the spring germinate on barberry leaves (Fig. 183), produce a new crop of cluster-cup spores, and so on. *Note that all these processes of spore formation are asexual; no gametes are known.*

335. Discussion. — The wheat rust is interesting to the botanist on account of its singular variety of methods of asexual spore formation. It is also of great practical importance, as it is a very dangerous enemy of the grain farmer. Comparatively rust-proof species of wheat are much in demand. Barberry bushes should never be allowed to grow in wheat-raising regions, and in many parts of England they have been nearly or quite exterminated by farmers. Where no barberries are found the rust is carried from one wheat crop to the next by uredospores only.

PSALLIOTA, ONE OF THE BASIDIA FUNGI

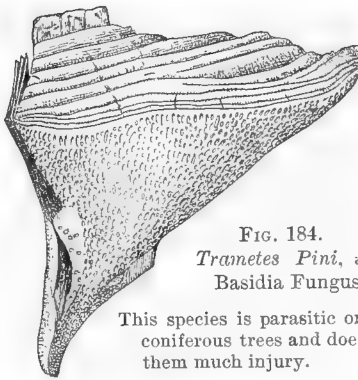


FIG. 184. *Trametes Pini*, a Basidia Fungus.

This species is parasitic on coniferous trees and does them much injury.

336. Occurrence. — The common mushroom, *Psalliota campestris* (often known as *Agaricus campestris*), grows in open fields and pastures in the United States and Europe. It is the mushroom most extensively cultivated for market, and if not found in the field it may be raised from "spawn" (mycelium), put up in the shape of bricks and sold by seedsmen in the large cities. Those who make a specialty of selling it furnish directions for culture. A moderately warm cellar or basement makes an excellent winter garden for mushrooms.

There are many other *gill fungi* of frequent occurrence besides the edible mushroom. Most of them are commonly known as toadstools. Any of these may be collected for

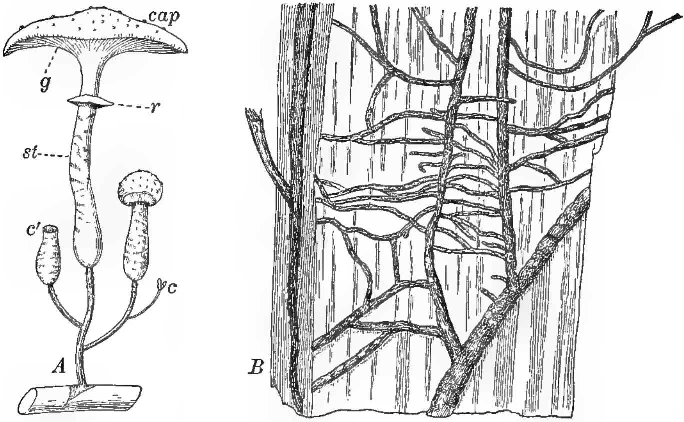


FIG. 185. *Armillaria mellea* (often known as *Agaricus melleus*).

This is a basidia fungus which can live either as a parasite or a saprophyte. As a parasite it is very destructive to the roots of coniferous trees. *A*, fructifications of various ages; *c*, *c'*, very young "buttons"; *st*, the stem or stipe; *r*, the ring (the remains of a membrane by which the margin of the cap was at first attached to the stalk); *g*, the gills. *B*, branching mycelium spread out between the bark and the wood of the root of the host.

study, though the directions which follow might require in some cases to be slightly modified for other genera than *Psalliota*.

337. Gross Structure. — Secure a group of perfect specimens which have been dug up with some of the mycelium attached. Note:

(*a*) The division into an aërial fruiting portion,[1] commonly called the mushroom, and the underground mycelium, or "spawn." Draw the entire portion above ground.

(*b*) The stages in the development of the cap and its stalk from the "buttons" (Fig. 185, *A*).

(*c*) The *cap*, *gills*, *ring*, and *stalk* of a fully developed mushroom. Observe the mode of origin of the ring.

[1] The word "fruiting" is often used with reference to spore-plants to apply to the spore-bearing portions or the spore-producing condition.

(*d*) The structure of the gills, as shown in a mushroom split lengthwise through the stem and cap and examined with the magnifying glass.

Cut off the stalk of a well-expanded mushroom or toadstool close to the cap and place the latter, gills down, on a sheet of paper. If the gills are light-colored use black paper, if dark-colored, white paper. After some hours lift off the cap and examine the print left by the spores.

(*e*) The extent of the mycelium as far as it can be traced in the earth or other substratum on which mushrooms or toadstools are growing.

338. Minute Structure of the Gills. — Cut thin sections of one of the gills at right angles to its flat surface. Mount and examine first with m.p. and then with h.p. If spores are not shown, as in Fig. 187, repeat with part of a gill from another mushroom. Note:

(*a*) The general structure of the gill, the interior consisting of loosely interwoven hyphæ and the external fruiting portion, the *hymenium*, consisting of ends of hyphæ definitely arranged. What is their position relative to the surface of the gill?

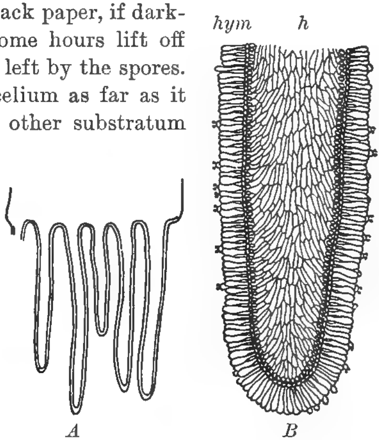


FIG. 186. Portions of Gills of a Fungus (*Agaricus*).

A, slightly magnified. *B*, one of the parts of *A*, more magnified; *hym*, hymenium; *h*, central layer.

(*b*) The *basidia*, or club-shaped tips of spore-bearing hyphæ.

(*c*) The *sterigmata*, or short stalks on the basidia, each sterigma bearing a spore.

(*d*) The size, shape, and color of the spores and the number borne by each basidium.

(*e*) The sterile filaments parallel to the basidia and lying between them.

339. Discussion. — The gill fungi (including most of the toadstools and mushrooms) are some of them saprophytic and some of them parasitic. A few may live in either fashion at will. The mycelium through which the plant obtains its nourishment is often so fine and inconspicuous that it escapes notice, and the fruiting portion is commonly thought to spring directly from the earth, bark, wood, or other substratum to which it is attached. *The reproduction is wholly asexual.*

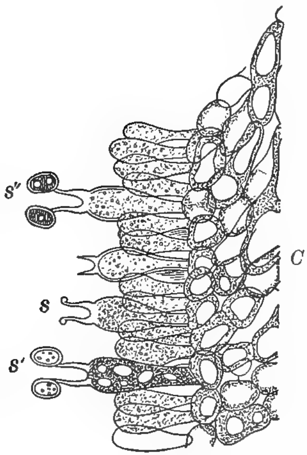


FIG. 187. Part of the Preceding Figure. (× about 300.)

C, layer of cells immediately under the hymenium. *s*, *s'*, *s''*, three successive stages in growth of spores.

Gill fungi are of considerable economic importance. A good many are edible (though others which resemble them are actively poisonous). Such parasitic species as *Armillaria mellea* (Fig. 185) are very injurious to timber. This fungus sends its mycelium through the bark or between the bark and wood of trees and often causes the death of the host.

A large shelf-fungus (*Trametes Pini*) of a closely related group (Fig. 184) is very destructive to trees of the Pine family.

The lack of sexual reproduction in organisms as complicated as the gill fungi seems to be evidence that these forms are degenerating. The same conclusion is suggested by the occurrence of what appears to be imperfect reproductive apparatus of *Puccinia* on the upper surfaces of infected barberry leaves. There is much other evidence of the same sort, and it all agrees with the supposition that fungi are degenerate descendants of algæ. Habits of parasitism, whether among animals or plants, very frequently cause them to become less perfectly developed than their nearest non-parasitic relatives.

The economic importance of some fungi has been already mentioned (Sects. 311, 313, 316, 326, 335). No sweeping statement can be made that fungi are generally useful or generally injurious. They benefit man not only by directly furnishing a few articles of food, but also by helping to destroy dead animal and plant matter. This would remain forever without decaying if it were not for saprophytic fungi, especially bacteria, and thus the available raw material for making plant food would soon be exhausted and all life and growth cease. Certain bacteria which live on the roots of plants of the Pea family serve to convert the nitrogen of the soil-air into nitric acid available for use by the plant to which the bacteria are attached. Vast amounts of food for animals are thus produced.

Fungi injure man by causing diseases in useful, wild, and cultivated plants, in domestic animals, and in human beings. The importance of bacterial diseases may be partly understood from one striking instance. The Black Death of the fourteenth century is considered to have been due largely to the attacks of the bacillus, which causes the bubonic plague. That single epidemic caused the death of about twenty-five million people.

340. Additional Notes on the Fungi. — Only a few species of fungi, out of some forty thousand that are known, have been outlined for laboratory work in the present chapter. The student can, however, hardly fail to learn from these studies something of the extreme diversity of fungi in almost every respect except the one general characteristic, inability to live on inorganic material, that is, to do the work of photosynthesis. *Fungi are therefore destroyers of food, and (like animals) on the whole lessen the total amount of organic matter on the earth, while green plants tend to increase it.* In fungi, formation of fat or oil, especially as reserve material, takes the place of the starch making so common in plants with chlorophyll.

As regards their mode of life, fungi may be roughly divided into three groups: (1) pure saprophytes; (2) plants which are saprophytic or parasitic according to circumstances; (3) plants which can only reach their full development as parasites. Several of the classes of fungi mentioned in Sect. 305 contain representatives of all three of the groups given above. The common mushroom is a familiar example of the first group, *Armillaria mellea* (Fig. 185) is a member of the second group, and the rusts of Figs. 181–183 belong to the third group.

CHAPTER XXVI

THE BRYOPHYTES

341. Classes of Bryophytes. — The bryophytes, or moss-like plants, are divided into:

CLASS 1. Liverworts.
" 2. Mosses.

It is not easy to state in an untechnical way all the distinctions between the two classes. One main difference is that most liverworts either show no distinction between stem and leaves, or if they possess leaves at all do not have

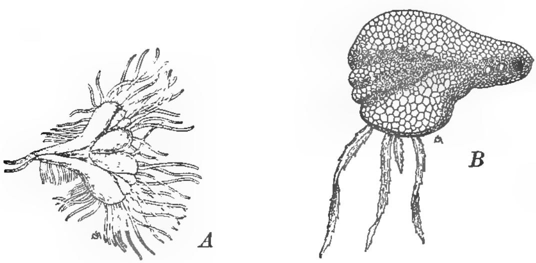


FIG. 188. *Ricciocarpus*, an Aquatic Liverwort.

A, whole plant, *gametophyte* (natural size); *B*, one lobe showing a few rhizoids. (Somewhat magnified.)

them arranged spirally. Moss leaves are borne in spiral rows. The whole plant body of the liverworts has an upper and an under side, while that of the mosses does not.

MARCHANTIA, ONE OF THE LIVERWORTS

342. Occurrence. — *Marchantia polymorpha,*[1] the commonest species of the genus, is widely distributed in this country and in Europe. It is found on damp soil or rocks, especially in shaded places.

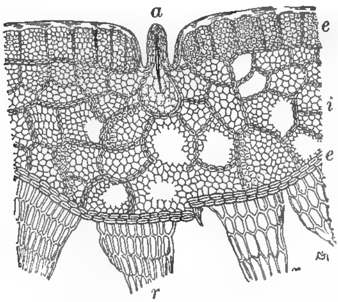


FIG. 189. Vertical Section through a Lobe of *Ricciocarpus.* (Magnified.)

a, antheridium; *e*, epidermis; *i*, spongy interior of thallus with air-chambers; *r*, bases of rhizoids.

343. Gross Structure. — Secure if possible specimens in the fruiting condition (Figs. 190, 191).[2] Examine with and without the magnifying glass and note:

(*a*) The size, shape, and color of the thallus or body of the plant.

(*b*) The mode of forking. Branches are formed in pairs on each side of the growing tip. Do they develop equally?

(*c*) The distinctions between the upper and the lower surface of the thallus. Look for scales on either surface and for *rhizoids* or root-like organs. Examine the upper surface with the magnifying glass and draw a portion of it, showing the diamond-shaped areas, each with a pore in its center.

(*d*) The *buds,* or organs of vegetative reproduction, small structures which, when detached, serve to produce new plants.

(*e*) The *male receptacles,* stalked disks with scalloped margins.

[1] If *Marchantia* cannot be easily obtained, *Lunularia,* a genus very common in greenhouses, may be substituted. It is easily recognized by the crescent-shaped cups in which the reproductive buds are borne. The structure is rather similar to that of *Marchantia* and the mode of vegetative reproduction is the same in both. *Lunularia* as found in our greenhouses does not undergo sexual reproduction.

[2] *M. disjuncta,* which is shown in these figures, differs considerably in the form of the receptacles from *M. polymorpha.* The male receptacle of the latter looks a good deal like the female receptacle of the former but is much shorter-stalked.

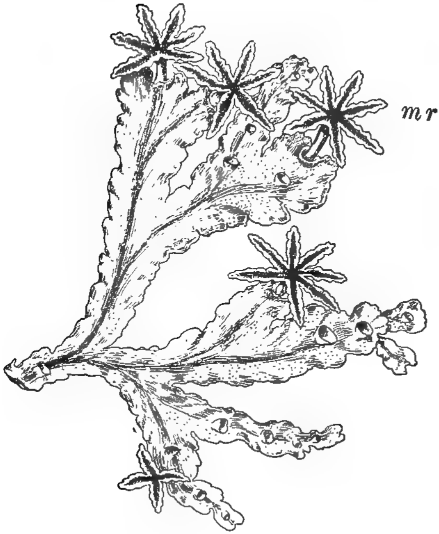


FIG. 190. Part of Male Thallus of a Liverwort (*Marchantia disjuncta*). (Enlarged.)

mr, male receptacle.

FIG. 191. Part of Female Thallus of *M. disjuncta*. (Enlarged.)

fr, female receptacle; *c*, cups with buds.

(*f*) The *female receptacles*, stalked structures with finger-like recurved arms radiating from the center. With the magnifying glass examine the under surface of a very mature receptacle and note the young *sporophytes*, or spore-plants, hanging from the receptacle. Draw.

FIG. 192. Section through Antheridial Receptacle of *Marchantia*. (Magnified.)

a, antheridium.

344. Minute Structure of Thallus and Buds. — Cut thin cross-sections of the thallus and examine with l.p. and then with m.p. Note:

(*a*) The general structure of the thallus, with a firm upper epidermis, spongy parenchyma beneath it (which serves for the storage of reserve food materials), and a thin lower epidermis.

(*b*) The air-chambers beneath the pores, each containing many short branching threads, made of pear-shaped cells. Compare these cells with others of the thallus as regards the number of chlorophyll bodies which they contain. What effect do these cellular threads have on the amount of surface for photosynthetic work in the air-chamber?

(*c*) The rhizoids. From which surface do they spring? Are they all alike?

Make a drawing to illustrate the general structure of the thallus, showing position of the air-chamber and attachment of the rhizoids. Make a detailed, highly magnified drawing of the air-chamber.

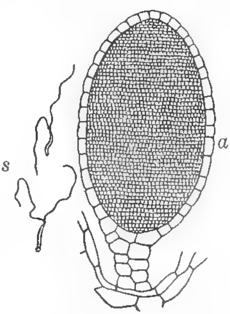


FIG. 193. Sectional View of an Antheridium of *Marchantia*.

a, antheridium; *s*, sperms. (× 700.)

Pick out from the cups several buds and examine them with m.p. Note:

(*a*) The shape of the buds.

(*b*) The notches which show the position of the *growing points* of the bud. How many are there?

(*c*) The minute stalk of each bud. How is this attached?

345. Minute Structure of the Male Receptacle and Antheridia. — Make thin vertical radial sections (in pith) of a male receptacle and examine with l.p. and m.p.[1] Note:

(*a*) The flask-shaped cavities in which the antheridia are borne. Where do they open?

(*b*) The antheridia of various ages, each with a stalk bearing a *sperm-case.*

(*c*) In water in which a fresh male receptacle has been left for a short time look with l.p. for moving sperms. Kill them with iodine, run water under the edge of the cover-glass, study, and draw. Or crush a mature antheridium from preserved material and study the sperms.

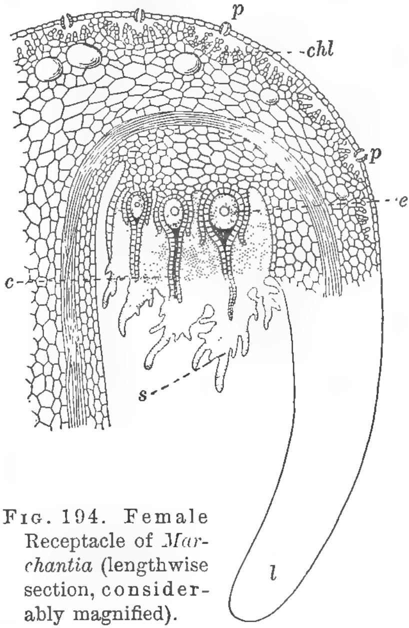


FIG. 194. Female Receptacle of *Marchantia* (lengthwise section, considerably magnified).

c, canal in neck of archegonium; *e*, egg in archegonium; *p*, breathing pore; *chl*, cells, in air-chamber, containing chlorophyll; *l*, lobe of the receptacle; *s*, fringed appendages of receptacle.

346. Minute Structure of the Female Receptacle and Archegonia. — Cut thin radial vertical sections (in pith) of young female receptacles, making the sections pass through the portions between the rays, or arms. If possible use also prepared slides of microtome sections. Examine with m.p. and note:

(*a*) The *archegonia* of various ages. Where are the youngest?

(*b*) The parts of an archegonium, — a short, stout *stalk*, an enlarged body, or *venter*, and a slender *neck*. Draw.

(*c*) Inside of the venter in the older archegonia an *egg*. Draw.

[1] Prepared slides of microtome sections will show the relative positions of the parts more clearly.

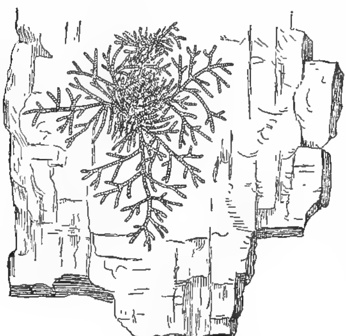
347. Minute Structure of the Sporophyte. — Pick out from old receptacles some of the full-grown sporophytes, mount, and examine with m.p. Note:

(*a*) The *foot* (which was imbedded in the receptacle), the slender *stalk*, and the enlarged *spore-case*. Draw.

(*b*) *Spores*.

(*c*) *Elaters*, spirally-marked cells which assist in scattering the spores. Draw (*b*) and (*c*) under h.p.

348. Discussion. — *Marchantia* is far more highly specialized for utilizing the raw materials of plant food than are any of the algæ or fungi studied in previous sections.



A

FIG. 195. *Frullania*, a Leafy Liverwort, growing on maple bark. (About natural size.)

Its thallus has a well-defined epidermis, especially firm on the upper surface to prevent undue loss of water. The rhizoids are efficient in absorbing water containing nutrient substances from the earth. The air-chambers beneath the upper surface of the thallus, with their hair-like chlorophyll apparatus, are admirably adapted for photosynthesis.

Asexual reproduction is well attained by the separation of young branches (set free by the dying of the older parts) and by the numerous buds.

The sexual reproduction is of a complicated character, brought about by the conjugation of unlike gametes.

349. Alternation of Generations. — In the reproduction of *Marchantia* for the first time in the studies of spore-plants outlined in Chapters XXIII–XXVII, the student fully encounters what is known as *alternation of generations*.[1] By this is meant the descent of a spore-bearing plant, or sporophyte, from a sexual plant, or gametophyte, then the descent of a gametophyte from the sporophyte, and so on indefinitely (see Sect. 357).[2] In *Marchantia* the sporophyte is a minute organism, incapable of separate existence and living much like a parasite on nourishment drawn from the female receptacle.

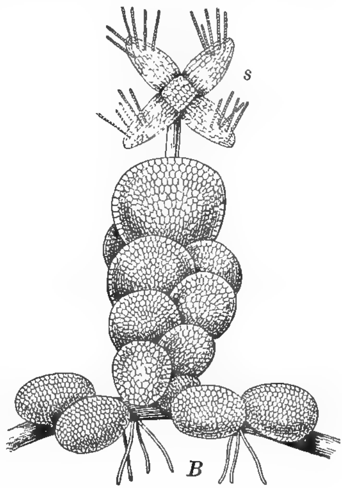


Fig. 196. A Small Portion of Fig. 195 enlarged.

s, the stalked spore-capsule.

350. Summary of the Liverworts. — The liverworts show a distinct advance in complexity over the algæ. This appears particularly in the excellent facilities possessed by such forms as *Marchantia* for photosynthesis and respiration, as land plants. It is also shown by the complicated process of sexual reproduction, maturing the egg in a many-celled archegonium and not in a one-celled organ such as is found among the thallophytes (*e.g.* Fig. 163). Alternation of generations is another indication of an advanced position in the plant world. It is important to note that while the majority of liverworts are terrestrial they all have ciliated sperms, a characteristic

[1] This also occurs in a less evident form in red algæ and in some sac fungi.

[2] The student may be asked to make a diagram of the life history of *Marchantia* on the plan of Fig. 203, or an illustrated one somewhat like Fig. 208.

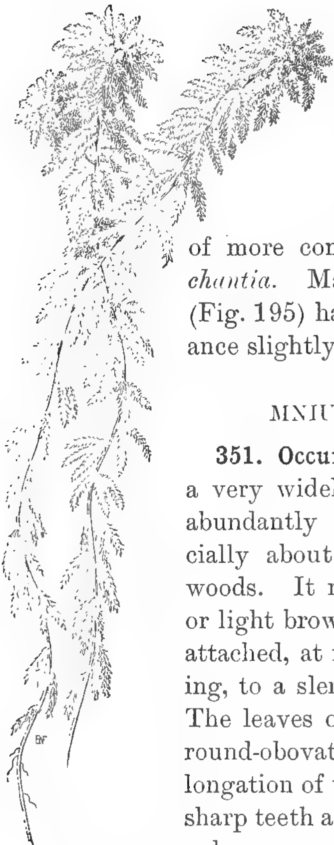


Fig. 197. Peat-Moss (*Sphagnum*).

of aquatic plants, and water is absolutely necessary to accomplish fertilization.

Some liverworts are minute floating plants (Fig. 188) much simpler than *Marchantia*, others are terrestrial, of more complex organization than *Marchantia*. Many of the higher liverworts (Fig. 195) have leafy stems and in appearance slightly resemble the mosses.

MNIUM, A COMMON MOSS[1]

351. Occurrence.—*Mnium cuspidatum* is a very widely distributed moss occurring abundantly on shaded ground and especially about the bases of trees in open woods. It may be known by the yellow or light brown ellipsoidal capsule, which is attached, at right angles or slightly drooping, to a slender stalk about an inch long. The leaves of the vegetative branches are round-obovate and pointed by a minute prolongation of the midrib. They have minute sharp teeth and, in fresh moist material, are pale green. The capsules are produced in the spring, and material showing various stages of development should be collected.

[1] Any of the common mosses, *Bryales*, will answer for this study. *Atrichum angustatum* is of frequent occurrence in woods and on sandy hills. *Funaria hygrometrica* is common on bare ground and especially on burnt-over places. Two species of *Bryum* are widely distributed, and *Polytrichum commune*, a very large moss, is found abundantly in open woods and pastures in the north.

FIG. 198. *Mnium undulatum*, a Moss.

A, female plant with four spore-capsules *s*; *B*, male plant with antheridia at *a*.

352. Gross Structure of the Complete Moss-Plant. — Procure a leafy plant with a capsule growing from it and note:

(*a*) The *stem*. Is it branched or unbranched?

(*b*) The *leaves*. How arranged?

(*c*) The *rhizoids*.

(*d*) The *sporophyte*, or spore-bearing plant, with a slender *stalk* bearing the capsule. Draw the leafy plant with the sporophyte × 2.

353. The Protonema.— Look in the neighborhood of patches of moss for a felt-like network of green threads covering the ground. It is most readily found on the earth of flower-pots in greenhouses. Mount some filaments in water and examine with m.p. Compare with Fig. 199. Invert a patch of moss in a plate with water, cover

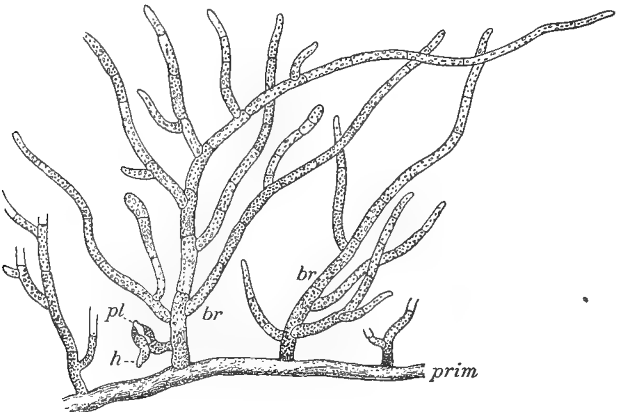


Fig. 199. Protonema of a Moss.

prim, primary shoot; *h*, a young root-hair; *pl*, young moss-plant; *br*, branches of primary shoot.

with a bell-glass in a sunny place, and note any changes that may after some weeks occur in the appearance of the exposed rhizoids. Explain.

354. Minute Structure of the Gametophyte, Vegetative Portion. — Examine with m.p. a microtome section of the stem near the base. Note:

(*a*) The *central strand* of small cells.

(*b*) Intermediate tissue of larger thin-walled cells, followed near the exterior by thicker ones.

(*c*) The epidermis.

(*d*) The *rhizoids* (not present on the upper parts of the stem) springing from the epidermis. Draw.

Examine a leaf with 2-inch objective and then with m.p. Note:

(*a*) The *midrib*, of mechanical cells.

(*b*) The *blade*, of thin-walled cells containing many chlorophyll grains.

(*c*) The *border*, of strengthening cells, some projecting into teeth. Draw.

355. Minute Structure of the Gametophyte, Reproductive Portion. — Dissect with needles, in water, on a slide, the tufts of leaves found at the tips of some stems.[1] Note:

(*a*) The *antheridia*, oval sacs growing from the enlarged tips; tips of the stem (see Fig. 201 for a single one much magnified).

(*b*) The *archegonia*, flask-shaped structures arising from the tip of the the stem (Fig. 202).

(*c*) The *sterile filaments* intermixed with the sex organs (Fig. 202.) Are the antheridia and archegonia of *Mnium cuspidatum* borne in the same leaf tuft or separately? Draw (*a*), (*b*), and (*c*) in position.

356. Minute Structure of the Sporophyte. — Procure plants showing sporophytes in various stages of development. Draw a series of these, attached to the tips of the leafy stems from which they grow. Boil some stems with attached sporophytes in five-per-cent potash solution for a few minutes, rinse with water, carefully pull out the sporophyte from the tip of the gametophyte, and

[1] It will be of decided advantage also to study prepared microtome slides of longitudinal sections of these tufts.

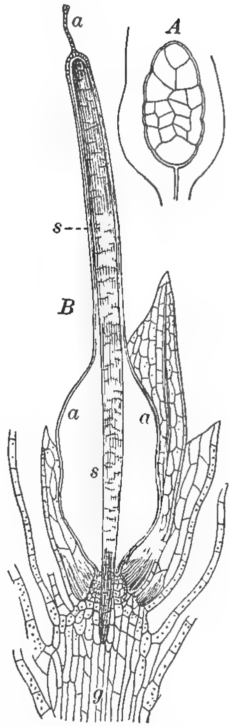


FIG. 200. Development of Sporophyte of a Moss (*Funaria*).

A, a very early stage, showing the cell-divisions of the egg; *B*, the sporophyte lengthening rapidly and about to tear off the archegonium, which will be carried up as the hood of the spore-capsule. The base of the sporophyte is fastened to the tissues of the gametophyte (leafy moss-plant), into which it is inserted for a considerable distance; *a*, archegonium; *g*, gametophyte; *s*, sporophyte.

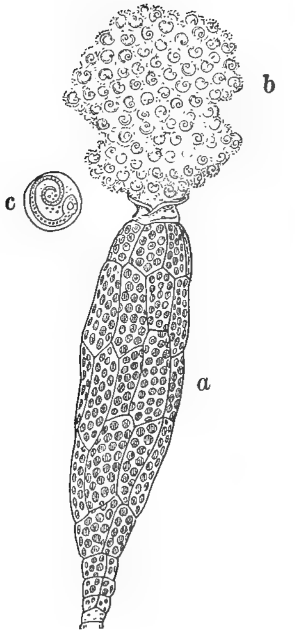


Fig. 201. The Antheridium of a Moss (*Funaria*) and its Contents.

a, antheridium; *b*, escaping sperms (× 350); *c*, a single sperm of another moss (× 800).

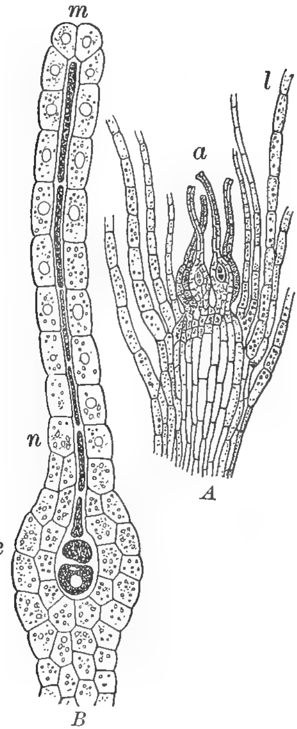


Fig. 202. Portions of Fertile Plant of a Moss (*Funaria*).

A, longitudinal section of summit of plant (× 100); *a*, archegonia; *l*, leaves. *B*, an archegonium (× 550); *e*, enlarged ventral portion with central cell; *n*, neck; *m*, mouth.

note the pointed foot which was imbedded in the gametophyte (Fig. 200).

Study young and full-grown sporophytes and note:

(*a*) The slender *stalk*.

(*b*) The enlarged *capsule*.

(*c*) The *hood* or *calyptra* which covers the young capsule. Cutting off and mounting in water the ends of capsules of various ages, examine with m.p. and note:

(*d*) The *lid* covering the mouth of the capsule.

(*e*) The fringe of *teeth* at the mouth. How many rows are there?

(*f*) The *spores* (best seen with h.p.).

Draw the structures above described (*a–f*).

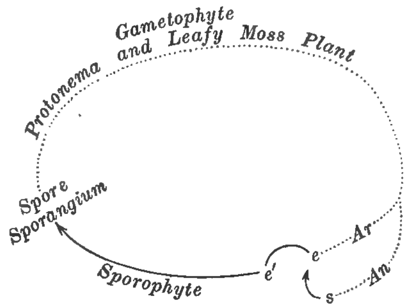


FIG. 203. Diagram of Life History of a Moss.

An, antheridium; *Ar*, archegonium; *s*, sperm; *e*, egg-cell; *e′*, egg.

357. Discussion.—The leafy moss-plant, or gametophyte, is more highly organized than such liverworts as *Marchantia*, since the moss has well-differentiated stems and leaves. It is also more specialized even than liverworts which bear leaves, since the moss stem has a more complicated structure than that of any leafy liverwort.

The sporophyte of mosses is more highly developed than that of most liverworts and far more so than the *Marchantia* sporophyte. The elevated position of the capsules and the expansion of the fringe of teeth at the mouth of each capsule assist in dispersing the spores. Although the sporophyte has some stomata and can do a little photosynthetic work, it must draw its supply of water and mineral matter from the leafy stem out of which it springs.

It therefore leads a half-parasitic life like such seed-plants as the mistletoe.

The life history of a moss is as follows: The spore on germinating forms a network of protonema, often of considerable extent. This protonema finally produces buds (Fig. 199, *pl*), which grow into leafy moss-plants (gametophytes). These bear the non-sexual sporophytes, and so on in a series of alternating generations (see Sect. 349).

Some mosses produce antheridia and archegonia in the same leaf-cluster, while others produce only one kind of sex organ in a cluster. In case the sexes are separated the male plants bear the antheridia at the summit within a sort of basin-shaped rosette or circle of specialized leaves, which are often colored (not green). The female plants bear the archegonia at the tips of the branches, where they are hidden by closely appressed leaves of the usual sort. Fertilization of the egg in the archegonium takes place when the sex organs are wet by rain or dew. The sperms are washed into the opening of the archegonium and make their way through the mucilage which fills its neck until they reach the egg at the bottom of the cavity.

358. Summary of the Mosses. — The mosses form a more united group than the liverworts, differing less among themselves in vegetative habit and in the details of their reproduction. None of the mosses are thallus plants and no whole order of mosses is aquatic, though some genera are so. Mosses are evidently far more successful plants than liverworts, as is shown by the fact that they are so numerous and so widely distributed. This is due in part to their reproductive power and also in part to the capacity of some of them to endure great extremes of heat and cold, moisture and dryness. The mosses, like the liverworts, have the aquatic character of possessing ciliated sperms, and water is necessary to accomplish fertilization.

359. Additional Notes on the Bryophytes. — The bryophytes are the lowest land plants which have stems and leaves. Some of the lower ones, like *Riccia* and *Marchantia*, have only a thallus and do not show a differentiation into stem and leaves. The bryophytes in this respect are intermediate between the thallus plants, such as algæ and fungi, and the pteridophytes, or ferns and fern-like plants (Sect. 360). Bryophytes have no fibro-vascular bundles. They are superior to the thallus plants in the complexity of their reproductive apparatus, developing the egg in a many-celled archegonium.

True roots are wanting in the bryophytes. In the liverworts one-celled rhizoids and in the mosses rhizoids consisting of simple rows of cells perform the work of roots.

Liverworts have no economic value and form but an insignificant part of the vegetation of the earth. Mosses, however, though none of them are very large plants, form an important part of the vegetation particularly of northern regions. Common mosses carpet large areas in woodlands and serve to prevent the rapid draining away of surface water after rains. In this way they help to maintain the constant flow of springs and rivers. Peat-mosses occur in immense numbers in bogs in various parts of the world. The dried moss is used as bedding for horses, and in a moist condition it is used by nurserymen and florists in packing plants. In extensive bogs large quantities of dead moss, sedges, and other plants may become accumulated under a layer of living plants, and the material resulting from their partial decay is known as peat. Dried (with or without compression into blocks) it is of use as fuel.

CHAPTER XXVII

THE PTERIDOPHYTES

360. Classes of Pteridophytes. — This series of the ferns and fern-like plants is, among other characteristics, distinguished from all other spore-plants by having much more highly developed tissues. From the presence of vessels the pteridophytes are often known as *vascular spore-plants.* They are divided into

Class 1. The ferns.
" 2. The horsetails.
" 3. The club-mosses.

The distinctions between these classes are some of them highly technical, but there are a few obvious characteristics which may be briefly stated.

The ferns have usually well-developed leaves, which are often highly compound (Fig. 204). They are frequently rolled up in the bud. Sometimes there are special spore-bearing leaves, but usually the spores are borne on the under surfaces of the ordinary foliage leaves.

The horsetails have very small undivided leaves, arranged in whorls. The spores are borne on specialized shield-shaped leaves, arranged in a sort of flower-like cluster (Fig. 211). The branches are whorled.

The club-mosses and their allies have mostly very small and simple, often scale-like or needle-like, spirally arranged

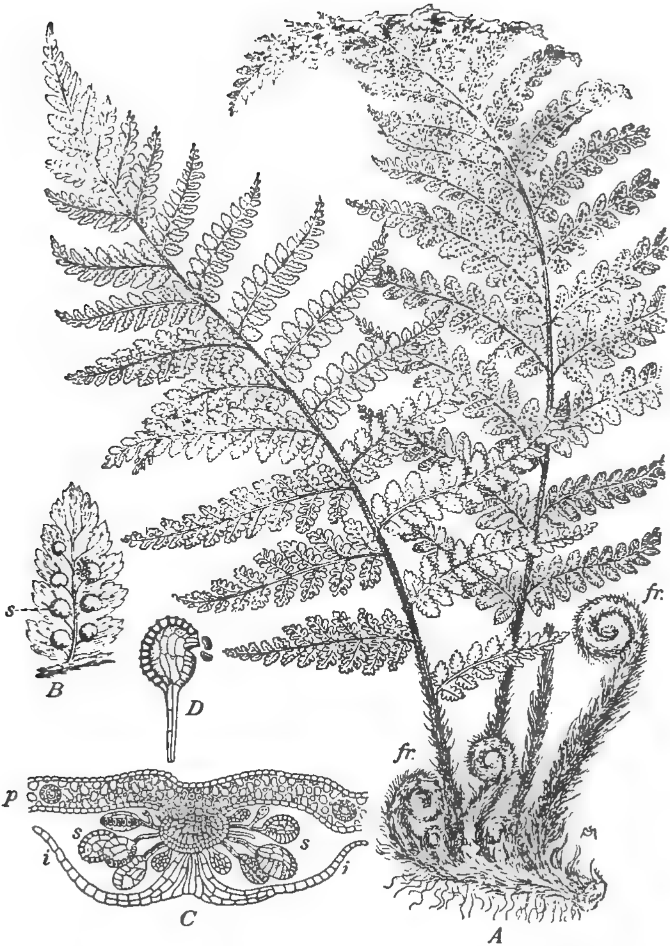


FIG. 204. Spore-Plant of a Fern (*Aspidium Filix-mas*).

A, part of rootstock and fronds, not quite one-sixth natural size; *fr*, young fronds unrolling (not usually found at the same season as the mature fronds); *B*, under side of a pinnule, showing sori *s*; *C*, section through a sorus at right angles to surface of leaf, showing indusium *i*, and sporangia *s*; *D*, a sporangium discharging spores. (*B* is not far from natural size. *C* and *D* are considerably magnified.)

leaves. In some cases the spore-bearing leaves are arranged in spherical cones (Fig. 213), while in others spores are borne by the ordinary leaves scattered along the stem.

361. Occurrence of Ferns. — Many of our commonest ferns are shade-plants, flourishing in moist woods, but there are widely distributed species, such as the bracken fern (*Pteris aquilina*), which grow readily in full sunshine. A few, such as *Notholæna*, *Cryptogramma*, *Polystichum*, and *Pellæa*, are decided xerophytes, growing usually on nearly bare rocks. Some species are highly local in their distribution, occurring only in a few localities, often of very limited area.

ASPLENIUM, A FERN

362. Gross Structure.[1] — Using fresh or preserved material for the underground portion and fresh material or dried and pressed herbarium sheets[2] for the portion above ground, note:

(*a*) The color, size, shape, and appendages of the rootstock.

(*b*) The mode of development of the leafy portion of the plant from the rootstock (Fig. 204).

(*c*) The mode of origin of the leaves, or *fronds*, from the rootstock and their general form and the amount and manner of division. The main axis is called the *rhachis*, the leaflets *pinnæ*, and their subdivisions *pinnules*. Draw a leaf.

(*d*) The *sori*, or *fruit-dots*, on the under surface of the leaves.[3] Draw a group of sori, as seen with the magnifying glass.

[1] This outline applies in detail only to *Asplenium filix-fœmina*, a species common in moist woods, though with slight modifications it will apply to any *Asplenium* and, in considerable part, to most genera.

[2] Fronds, or parts of fronds, may also be mounted like *passepartout*-framed pictures, between two sheets of glass, and are very convenient to pass from hand to hand, showing both sides of the frond.

[3] In the bracken fern (*Pteris*) and the maidenhair fern (*Adiantum*) the spore-cases are borne near the edges of the leaves and covered by the incurved edges of the frond.

Photograph by Soule Photograph Co.

PLATE XI. Tree Ferns.

363. Asexual Reproduction, Spore-Cases and Spores.[1] — Pick out some spore-cases from a sorus (Fig. 204, *C*, *D*), mount them in water, examine with l.p., and note:

(*a*) The stalk.

(*b*) The spore-cases proper. Draw.

(*c*) The partial ring of thick-walled cells enclosing the spore-case.

(*d*) The spores. These should also be examined with h.p. Draw.

The spores are scattered by the splitting open of the spore-case when very dry, pulled apart by the elastic ring (Fig. 204, *D*).

364. The Gametophyte (Prothallium) and Sexual Reproduction. — Material for this study may be obtained by dusting spores of any desired species of fern over bits of brick or broken flower-pots or earth kept moist under a bell-glass. The spores of most genera are long-lived and germinate readily many months after they mature. They should be sown six weeks or more before the material is needed for class use. Germinating spores in all stages of development may also be found on flower-pots containing greenhouse species of fern, particularly *Adiantum*. Mount some of the material, examine with h.p., and note:

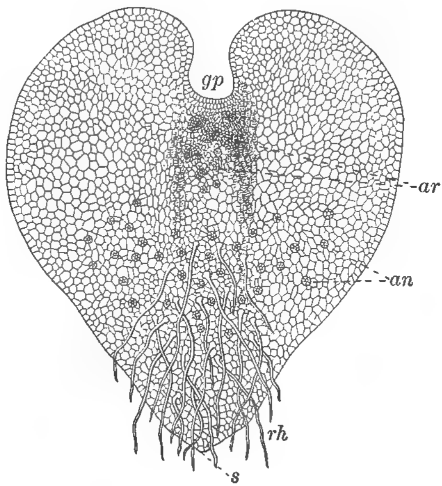


FIG. 205. Prothallium of a Fern (*Polystichum*). View of the under surface.

gp, growing point; *ar*, archegonia; *an*, antheridia; *rh*, rhizoids; *s*, region in which the spore germinated. (× about 8.)

(*a*) Several stages in the germination of spores. Draw.

[1] Polypodium is excellent material for the study of the sporangia. The minute structure of the vegetative portion of the fern is here omitted.

(*b*) Fully formed prothallia (Fig. 205) with antheridia, archegonia, and rhizoids. These may best be seen with l.p. in a prothallium that has been held by delicate forceps and washed with a gentle stream of water from a wash-bottle. The prothallium should then be mounted, bottom side up, in a concave ground-slide and examined as an opaque object and also by transmitted light.

(*c*) Prothallia which are developing young fern-plants (Fig. 206). In some of these study with h.p. the distribution of the chlorophyll

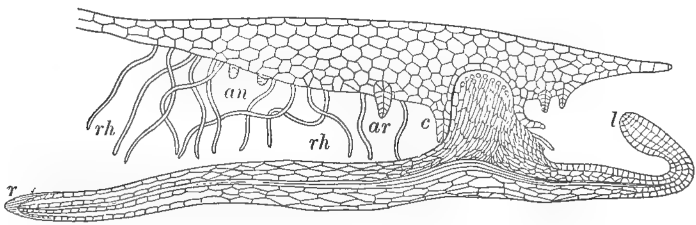


FIG. 206. Development of the Sporophyte of a Fern. Vertical section through prothallium.

an, antherozoids; *ar*, archegonia; *c*, thickened cushion, in which the foot of the young fern-plant is imbedded; *rh*, rhizoids; *l*, first leaf; *r*, root. (Magnified.)

bodies in cells of the prothallus. Draw. Study with l.p. the structure and veining of the young fern leaf. Draw.

Procure some dwarf prothallia that have been growing much crowded together and then kept for a day or two with very little water. Mount in water, examine with h.p., and look for:

(*d*) Antheridia best seen on the margin of the prothallium. Draw.

(*e*) Sperms, swimming about in the water. Stain these with iodine and draw, showing the body of the sperm and its tuft of cilia.

In prepared slides, if any are attainable, study the structure of an archegonium, noting:

(*f*) The enlarged ventral portion.

(*g*) The elongated neck. Neck canal cells and ventral canal cell.

(*h*) The egg within the ventral portion.[1] Draw.

[1] See Bergen and Davis' *Principles of Botany*, pp. 316, 317.

365. Discussion. — The life history of a fern differs in a striking way from that of a liverwort or moss. Ascending

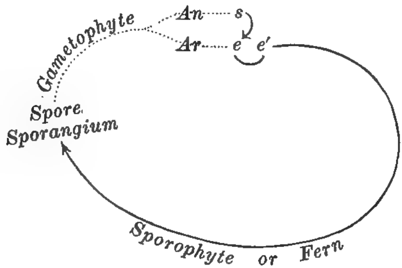


Fig. 207. Diagram of Life History of a Fern.

An, antheridium; *Ar*, archegonium; *s*, sperm; *e*, egg-cell; *e′*, egg.

from the lower forms of plant life to the higher ones, it is only when the ferns are reached that *alternation of generations* is shown in its most complete form. By this term a

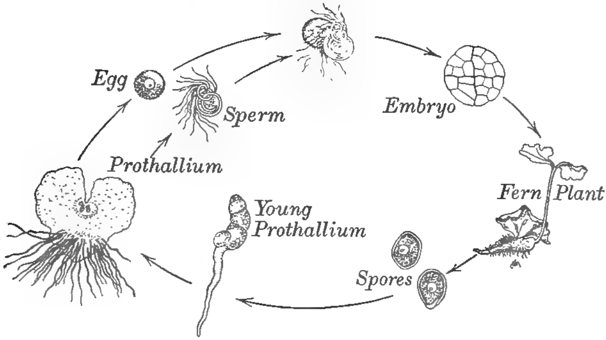


Fig. 208. Illustrated Life History of a Fern.

(The young fern-plant is *Onoclea*, Fig. 209.)

process of reproduction is meant in which the offspring resemble closely not the parent but the grandparent, as is shown in the diagram (Fig. 208). In the mosses and their allies the full-grown plant is a gametophyte, and the spore-bearing plant or sporophyte appears as a sort of parasitic outgrowth of the gametophyte (Sect. 357). In the ferns and their allies the full-grown plant (that which we commonly call a fern) is an asexual sporophyte, amply provided with vegetative organs, *i.e.* roots, stem, and leaves, often capable of living for many years and attaining the dimensions of a tree. The gametophyte (prothallium) in ferns is a minute, usually short-lived structure, and exists simply to mature an egg which may produce a fern-plant.

FIG. 209. Sensitive Fern (*Onoclea*).
s, sterile or vegetative frond; *f*, fertile frond or sporophyll.

366. Summary of the Ferns. — Most ferns are land plants, but there is one order of aquatic ferns, some of which live floating freely in water and others grow rooted in the mud. Ferns vary greatly in size, the smallest genera not being nearly as large as some mosses, while others are tree-like. With abundant vessels, rigid tissue for strengthening purposes, and various kinds of parenchymatous tissue set apart for different offices in the stem and leaves, ferns have a higher vegetative organization than the simplest seed-plants. The leaves are well furnished with stomata and the work of photosynthesis is amply provided for. Pteridophytes constitute the lowest group of plants which have *true roots.*

The reproductive processes of ferns are of a higher grade than those of liverworts and mosses, but not as highly developed as those of horsetails, club-mosses, and *Selaginella* (Sects. 371, 374).

FIG. 210. A Water Fern (*Marsilia*).
s, spore fruits.

EQUISETUM, A HORSETAIL

367. Occurrence. — The commonest horsetail, *Equisetum arvense*, occurs widely distributed throughout the United States. It is frequently found growing on railroad embankments and on sand-hills. The fruiting stems appear very early in the spring and are short-lived. The sterile vegetative stems follow and become well grown during June.

368. Gross Structure. — Make use of herbarium sheets of plants with fertile and with sterile stems, or sheets of one and fresh material of the other.

I. Study the position, form, and size of the rootstocks and the places at which roots and stems arise from these. Are there any attached tubers?

II. Study the fertile stems, noting:

(*a*) The shape of the stem as a whole. Is it solid or hollow?

(*b*) The circle of sheathing leaves at each node. Are the leaves entirely separate from one another? Split a stem lengthwise through a node and examine it with the magnifying glass.

(*c*) The cone at the summit of each stem, composed of spore-bearing scales. Examine these scales with the magnifying glass to determine their shape. Draw the fertile stem.

III. Study the sterile stems, noting:

(*a*) The position, arrangement, and number of the branches.

(*b*) The form of the branches and their resemblances to and differences from the stem. Draw part of a sterile stem and a slightly magnified branch.

369. Minute Structure. — Cut thin sections of a fertile and a young sterile shoot between the nodes.[1] Mount in water and examine with l.p. and m.p. Note:

(*a*) The general shape of the section.

(*b*) The external grooves and ridges.

(*c*) The stomata.

(*d*) The position of the portions of tissue containing chlorophyll. Is it present in both kinds of stem?

(*e*) The fibro-vascular bundles.

(*f*) The air-passages, one in the center and two other sets surrounding it. Draw.

370. The Spore-Leaves. — Using fresh or preserved material, pick off a few spore-leaves from one of the cones. Put them in water in the cavity of a slide with concave center. Examine with the magnifying glass, or, if convenient, with a two-inch objective. Note:

(*a*) The stalk of the spore-leaf.

(*b*) The number and mode of attachment of the *sporangia*, or cases in which the spores are produced. Draw.

Tease apart some sporangia in water, mount, and examine with m.p. Note:

(*c*) The spores, with attached bands known as *elaters*. Mount in water some fresh spores or those that have been merely dried, examine without a cover-glass, and note the movements of the elaters as the water evaporates. Draw.

[1] Sections of the mature sterile stems are difficult to cut. Prepared slides of these and (for comparison) of one of the large perennial-stemmed species, as *Equisetum hiemale*, may be bought of dealers in microscopical material.

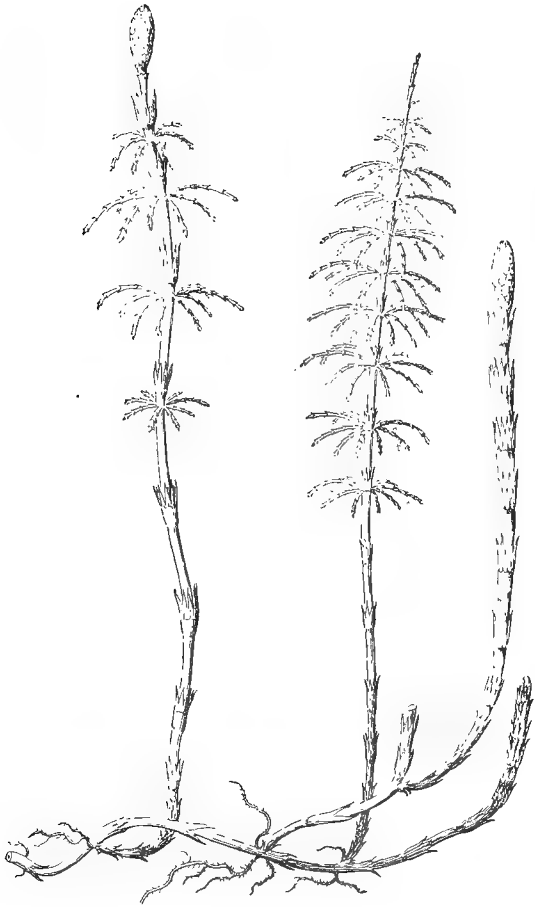


FIG. 211. A Horsetail (*Equisetum sylvaticum*).

At the right is a colorless fertile stem, in the middle a green sterile one, and at the left a green fertile one.

371. Discussion. — The horsetails of the present day number only about forty species, but they are the insignificant descendants of what was in earlier times a highly important class of plants, often tree-like in size.

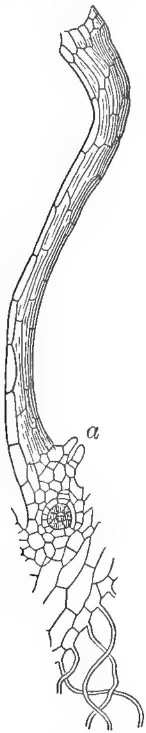


FIG. 212. A Lobe of the Mature Female Prothallium of *Equisetum*. (× about 50.)

a, mouth of a fertilized archegonium.

The work of photosynthesis in *Equisetum* is wholly performed by the green tissue of the stems and branches, not at all by the scale-like leaves. The stomata occur in the channels which run lengthwise of the stems. The thick flinty epidermis and well-developed rigid tissue under the epidermis, together with the moderate amount of plant-surface exposed to the air, make the horsetails decidedly xerophytic in their structure.

Some horsetails, particularly *E. hiemale*, have so much silica in the epidermis that they were formerly much used and are still somewhat employed to polish tinware and other metal surfaces. Hence were derived the common names scouring-rush and gunbright. *Equisetum* differs from ferns in having the spore-bearing leaves grouped into a cone. This is a distinct advance toward the flower-bearing condition of seed-plants. The species of *Equisetum* studied has pale fertile stems, living almost like parasites at the expense of material drawn from the rootstock and wholly set apart for spore production.

Other species, however, like *E. sylvaticum* (Fig. 211) and *E. hiemale*, have part or all of the stem both green and fertile.

The gametophytes of *Equisetum* are produced from the germinating spores very much as are those of ferns. The prothallia are always of one sex only, and the female ones are of a very irregular shape, having many lobes (Fig. 212). From the manner in which the spores cling together by means of their elaters, male and female prothallia are likely to grow side by side and thus insure fertilization.

While the *ferns*, *horsetails*, and *club-mosses* are essentially land plants, they all show their aquatic ancestry (as do the bryophytes) by the possession of ciliated sperms. That period of their life history which is concerned with sexual reproduction is distinctly aquatic. The presence of water is absolutely necessary in order that the sperms or male gametes may swim to and reach the archegonia and thus bring about the fertilization of the egg.

THE CLUB-MOSSES[1]

372. Occurrence. — The best-known and most conspicuous club-mosses belong to the two genera *Lycopodium* and *Selaginella*. The former is well represented in the woods of temperate climates and is well known throughout much of the United States as "Christmas evergreen," largely used in holiday decorations. *Selaginella* occurs to some extent in temperate climates, but most of the five hundred species[2] are tropical.

[1] As the detailed study of the *Lycopodineæ* is mainly interesting on account of its bearing on the evolution of plants, no laboratory work is here given.

[2] This number is only approximate.

373. Form and Structure. — The general appearance of many species of *Lycopodium* is very similar to that shown in Fig. 213. *Selaginella* is most familiar to people who are not botanists from the species often grown in greenhouses.

FIG. 213. Plant of Lycopodium (*L. annotinum*).

It has somewhat the appearance of a large leafy moss-plant, with the leaves arranged in four rows.

The structure of the stems and leaves of the club-mosses is somewhat complex. They have well-developed fibro-vascular bundles with sieve-tubes.

374. Reproduction; Heterospory. — In *Lycopodium* the leafy (asexual) plant produces an immense number of spores from spore-leaves which are sometimes grouped in a cone at the end of the stem and sometimes scattered along the stem. No gametophytes of our species of the northern United States have been found, and therefore reproduction in these must be by division of the stem or by certain buds specialized for this purpose. *Selaginella* produces two sorts of asexual spores. Of these the smaller kind develops into male and the larger into female gametophytes. From the fertilized female gametophyte a young (asexual) spore-plant is produced.

The term *heterospory* is applied to the condition of plants which (like *Selaginella*) bear two kinds of asexual spores from which are developed two kinds of gametes. Heterospory begins among the pteridophytes with certain ferns (Sect. 382), though most ferns have all their spores alike. The highest of all plants (seed-plants) are heterosporous, producing a smaller kind of spore, the pollen-grain, and a larger kind, the embryo sac (Sect. 383). An important result of heterospory is that the gametophyte becomes extremely small, remaining partially or almost wholly enclosed in the spore from which it is developed. This dwarfing of the gametophyte is one of the most noteworthy steps which mark the rise of the highest of the pteridophytes and the seed-plants from all lower spore-plants.

375. Additional Notes on the Pteridophytes. — As has already been suggested in regard to the horsetails (Sect. 371), the pteridophytes in general are of much less importance at present than they were in earlier geological ages.[1] Tree-like club-mosses were extremely abundant during the age when most of the earth's coal deposits were formed (the Carboniferous Age), and a large part of the bulk of

[1] See Bergen and Davis' *Principles of Botany*, Chapter XXV.

our coal is made up of the trunks and branches of these great plants and even of their enormously abundant spores.

The leaves and stems of extinct species of ferns and of primitive gymnospermous trees are also important constituents of coal. Tree-like plants allied to the horsetails were conspicuous features of the Carboniferous landscape, and their remains are characteristic fossils in many coal deposits, but they did not contribute much to the fuel value of the deposits. Our knowledge of the luxuriant vegetation from which coal was made has been gained from the study of the fossil plants and parts of plants recognizable in coal itself and in the rocks which lie beneath or above it. In some instances the roots of trees are found well preserved in underlying clays, while their trunks and branches rise through the coal seams above. It is probable that some coal beds have been derived from immense peat bogs (Sect. 359).

Living pteridophytes are of little economic importance. Many species of ferns and some of *Selaginella* are cultivated for ornament. The rootstocks of one species of fern are somewhat used in medicine, young shoots of the bracken fern are edible, and the spores of various species of *Lycopodium* are still occasionally used by apothecaries to dust over the surfaces of pills and for other purposes.

CHAPTER XXVIII

SUMMARY OF THE HISTORY AND CHARACTERISTICS OF THE PLANT KINGDOM[1]

376. The Plant World Originally Simpler. — Plants as we see them about us to-day are of all degrees of size and complexity from bacteria to the highest seed-plants. However, it would be a serious mistake to think of the plant kingdom as always having been as complex as this, or to suppose that the plants which now coexist have always coexisted. Any one looking over the surface exposed in a gravel-pit may perhaps find a stone spear-head made hundreds of years ago (and of a pattern thousands of years old) beside a cartridge shell of last year's model. But unnumbered generations of men flourished and died between the period of the first spear-head and that of the first metallic cartridge, and both kinds of objects have never been manufactured in any region at the same time.

The exact time at which plant life first made its appearance on the earth is unknown; — it must at least have been many millions of years ago.[2] The precise kind or kinds of plants which first appeared cannot now be determined.

[1] A large library of books on the topics outlined in this chapter could easily be accumulated. Some important titles may here be referred to by their numbers as given in the bibliography of Bergen and Davis' *Laboratory and Field Manual of Botany*, — see numbers 1, 3, 36, 37, 66–70.

[2] In such a brief and elementary presentation of plant evolution as is given in the present chapter conclusions must be stated without much attempt to show the process of reasoning upon which they are based.

It is fairly certain that they were of the simplest structure, probably far below any of the more highly developed algæ.

377. The Earliest Plants akin to Animals. — It is easy in the case of the higher members of both kingdoms to state the differences between plants and animals. No one can fail to distinguish between the grazing animal and the grass on which it feeds.

Most Animals	Most Plants[1]
1. Obtain carbon from carbohydrates or oil made by plants or other animals.	Obtain carbon from carbon dioxide in air or water.
2. Obtain nitrogen from proteids and so on.	Obtain nitrogen from nitrates in soil.
3. Have no chlorophyll.	Have chlorophyll.
4. Have not cell-walls of cellulose.	Have cell-walls of cellulose.
5. Have great division of labor among the cells.	Have little division of labor among the cells.
6. Are mainly consumers of food and use much of the energy derived from their food in locomotion.	Are mainly producers of food and use little or no energy in locomotion.

There are many exceptions to the statements above given; as, for instance, fungi fail to conform to the characteristics given under the headings 1, 2, 3, and 6. Some of the lowest known organisms, such as the slime-molds

[1] See Thomson's *Outlines of Zoölogy*, Chapter II, D. Appleton & Co., New York.

(Fig. 214) and the flagellates,[1] have so many characteristics common to plants and animals that they are described both in botanies and zoölogies, are spoken of now as plants, now as animals, and really belong to a borderland between the animal and the plant kingdom. Flagellates frequently have the animal characteristic of taking particles of solid food through a funnel-like depression, and they resemble animals in their power of swimming freely about. Some of them resemble plants in their possession of chlorophyll and power of using carbon dioxide in photosynthesis.

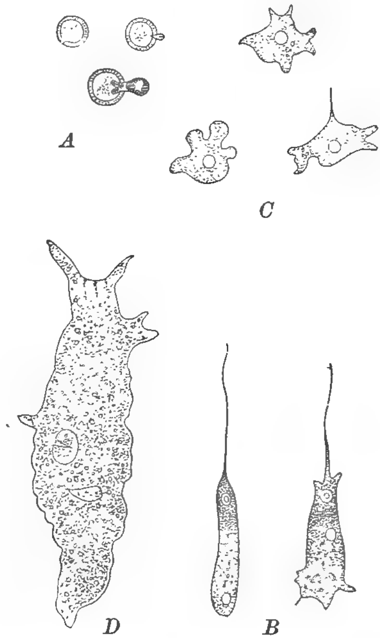


FIG. 214. Slime-Molds. (× 350–390.)

A, spores, two of them germinating; *B*, swarm-spores; *C*, creeping, animal-like (*amœbiform*) condition; *D*, naked mass of protoplasm (*plasmodium*) produced by the union of many individuals like *C*.

We cannot say that the plants of higher organization are descended from such forms as the slime-molds and the flagellates. But since these constitute a kind of link between animals and plants and are of simpler structure than most other living beings, it is not improbable that all living organisms are the modified offspring of lowly forms not unlike those of Fig. 214. A more immediate ancestor

[1] Bergen and Davis' *Principles of Botany*, Sect. 204.

of the higher green plants is probably to be found among the remarkable group of algæ (*Volvocaceæ*) to which *Volvox*, *Pleodorina* (Fig. 215), and similar colonial forms belong.

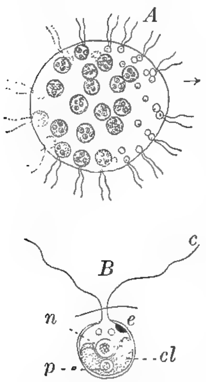


FIG. 215. *Pleodorina*, a Colonial Green Alga.

A, a cell-colony (magnified) swimming by means of cilia in the direction shown by the arrow; *B*, one of the smaller cells (much magnified), showing the long cilia *c*, the eye-spot *e* (supposed to be sensitive to light), the nucleus *n*, the pyrenoid *p*, and the cup-shaped chloroplast *cl*.

378. Remains of the Earliest Plants not Preserved. — The rocks in many parts of the earth's crust contain fossil remains of plants, often in enormous numbers (Sects. 303, 375). But we may fairly suppose that none of the earliest plants are thus preserved, on account of their soft and perishable nature. This must have made it difficult for them to leave impressions in beds of mud or sand, or for them to last long enough to let limestone or other substances gradually become deposited, instead of the material of the plant. Since the first plants were swept out of existence ages ago, our knowledge of their form, structure, and relationships to later plants must be drawn from studies of the types which we know, either in the shape of fossils or as living species.

379. Evidence from the Life Histories of Plants. — Every individual seed-plant and every one of the higher spore-plants during its life history goes through a series of changes, — from the spore with which it begins to the most highly developed form of which that plant is capable. This gradual unfolding of organs, from a very simple spore as the starting point, means everything to the botanist. For in botany, as in zoölogy, it is a well-recognized law that *the development of every individual usually follows in outline the course of development of its group*. During the process of hatching, while the young animal in the egg is beginning to develop into a turtle, an alligator, or a bird, the general form of the embryo is for some time much the same in all three cases. It is probable that this arises from the fact that turtles, alligators, and birds have sprung from a common ancestor, — an animal which lived in the far remote past and which united in its organization some of the characteristics of these its descendants.

Reasoning in this same way, we may, for example, feel sure from the resemblance in essentials between the prothallia of ferns and horsetails that these two kinds of plants, so different in the general form and structure of the full-grown sporophytes, have a common ancestry. This is only one rather simple instance, out of many, of likeness in the early stages in the life history of two classes of plants which are most unlike in their adult condition. By comparing in this way the successive steps in the development of great numbers of plants of different groups, it has become possible to draw up a sort of pedigree of the plant world. This is not as yet by any means complete, but what is already known on the subject throws much light on the reasons for the existence of structures in the early part of the life histories of many plants which would otherwise seem to be wholly useless and without meaning.[1]

380. Plants form an Ascending Series. — All modern systems of classification group plants in such a way as to show a succession of steps, often irregular and broken,

[1] See Bergen and Davis' *Principles of Botany*, pp. 243, 273, 404, 405.

seldom leading straight upward, from very simple forms to complex ones. The humblest thallophytes are merely single cells of microscopic size. Class after class shows an increase in complexity of structure and of function until the most perfectly organized plants are met with among the dicotyledonous angiosperms. During the latter half of the nineteenth century it first became evident to botanists that among plants *deep-seated resemblances imply actual relationship, the plants which resemble each other most are most closely akin by descent, and (if it were not for the fact that countless forms of plant life have wholly disappeared) the whole plant kingdom might have the relationships of its members worked out by a sufficiently careful study of the life histories of individual plants and the likenesses and differences of the several groups which make up the system of classification.*

381. Development of the Plant from the Spore in Green Algæ and Mosses. — The course which the forms of plant life have followed in their successive appearances on the earth may be traced by the application of the principle stated in Sect. 379.

Such algæ as the pond-scums produce spores which give rise directly to plants like the parent.

A moss-spore in germination produces a thread-like protonema which appears very similar to algæ of the pond-scum sort. This at length develops into a plant with stem and leaves, — the sexual generation of the moss. The fertilized archegonium matures into a sporophyte which is the alternate non-sexual generation. This is attached to the moss-plant or gametophyte, but is an important new organism. In the moss the sexual generation is the larger and more complex of the two, the non-sexual generation being smaller and wholly dependent for its food supply on the other generation to which it is attached.

382. Development of the Plant from the Spore in Pteridophytes. — In the pteridophytes there is an alternation of generations, but here the proportions are reversed, the prothallium, or sexual generation, or gametophyte, being usually short-lived and small (sometimes microscopic), and the non-sexual generation, the sporophyte, often being of large size. The ferns (non-sexual generation), for instance, are perennial plants, some of them tree-like. Some pteridophytes, as the *Salvinia*, a small, floating aquatic plant sometimes known as a water-fern (Fig. 216), produce two kinds of spores, the large ones known as *megaspores*, and the small ones as *microspores* (Fig. 217). Both kinds produce microscopic prothallia, those of the former bearing only archegonia, those of the latter only antheridia. From the prothallia of the megaspores a plant (non-sexual generation) of considerable complexity of structure is formed.

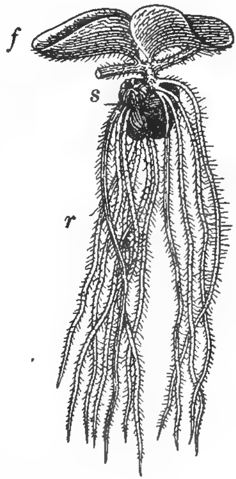


FIG. 216. A Water-Fern (*Salvinia*).

f, floating leaves; *r*, submerged leaves, acting as roots; *s*, spore-fruits.

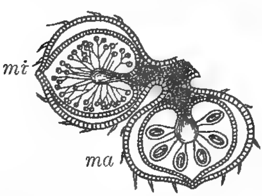


FIG. 217. Two Indusia of *Salvinia*.

mi, microspores; *ma*, megaspores.

383. Parts of the Flower which correspond to Spores. — In seed-plants the spore-formation of spore-plants is represented, though in a way not at all evident without careful examination. The pistil is the megaspore-producing leaf, or *megasporophyll*, and the stamen is the microspore-producing leaf, or *microsporophyll*. Pines and other gymnosperms produce a large cell (the embryo sac) in the ovule (Fig. 218) which is the megaspore, and a pollen grain which is the microspore. In its development the megaspore produces an endosperm or small cellular prothallium, concealed in the ovule. The microspore contains vestiges of a minute prothallium.

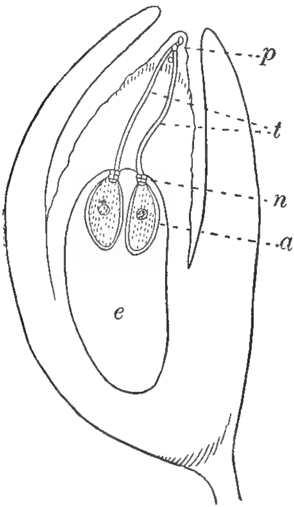


Fig. 218. Longitudinal Section through Fertilized Ovule of a Spruce.

p, pollen grains; *t*, pollen tubes; *n*, neck of the archegonium; *a*, body of archegonium with nucleus; *e*, embryo sac filled with endosperm.

In the angiosperms the megaspore and its prothallium are still less developed, and the microspore, or pollen grain, has lost all traces of a prothallium and is merely an antheridium which sooner or later produces two generative cells. These are most easily seen in the pollen grain, but sometimes they are plainly visible in the pollen tube (Fig. 123, *B*).

Seed-plants are distinguished from all other plants by their power of producing seeds, or enclosed *megasporangia* with embryos.

384. The Sexual Generation and Relationships of the Great Groups of Plants. — On summing up Sects. 381–383 it is evident that the sexual generation in general occupies a less and less important share in the life of the plant as one goes higher in the scale of plant life.[1] In the case of the rockweed, for instance, the sexual generation is the plant. Among mosses the sexual generation is still very prominent in the life of the plant. Ordinary ferns show us the sexual generation existing only as a tiny independent organism, living on food materials which it derives from the earth and air. In the *Salvinia* it is reduced to microscopic size and is wholly dependent on the parent plant for support. Among seed-plants the sexual generation is so short-lived, so microscopic, and so largely enclosed by the tissues of the flower that it is comparatively hard to demonstrate that it exists.

The fact that the life history of so many of the classes of plants embraces a sexual stage, in which an egg-cell is fertilized by some sort of specialized cell produced wholly for use in fertilization, tends strongly to show the common origin of the plants of all such classes. We have reason to believe, from the evidence afforded by fossils, that plants which have only a sexual generation are among the oldest on the earth. It is therefore likely that those plants which spend the least portion of their entire life in the sexual condition were among the latest to appear. Then, too, those which have the least developed sexual generation are among the latest of plants. Judged by these tests, the angiosperms must be the most recently developed of all plants.

If one were to attempt to arrange all the classes of existing plants in a sort of branching series, to show the way in which the higher plants have actually descended from

[1] A good many plants of low organization, however, are not known to pass through any sexual stage.

the lower ones, he would probably put some one of the green algæ at the bottom and the angiosperms at the top of the series.

385. The Oldest Angiosperms. — It is impossible to give any of the reasons for the statements of this section without making an unduly long chapter. It is not yet certain whether monocotyledons or dicotyledons were the first to appear on the earth. The descent and various relationships of the families of dicotyledons can be discovered by the study of the flower, fruit, and seed better than by the examination of the vegetative organs.

The entire pedigree of the several families cannot be represented by arranging the names of the families in a straight line. Their relationships can be shown, however, in a general way, and a part of the pedigree is indicated by the succession of families in the Flora which accompanies this book. The Willow family is perhaps the oldest of the more familiar families of dicotyledons, and the Composite family the youngest. The beginner must remember that it is not such "typical" flowers as are shown in Figs. 97 and 98, but rather bilaterally symmetrical ones like Fig. 101, or epigynous and closely grouped flowers like those of the Composite family (Appendix I, Fig. 8), that represent the highest development among flowers.

386. Division of Labor and Plant Evolution. — A little has been said in Sect. 384 about the steps of development in the reproductive processes of plants. In general the more complicated kinds of reproduction are found among the younger and higher types of plants. The same general law applies to the vegetative parts of the plant body.

The lowest undoubted plants (Figs. 150, 169) show very little division of labor among their parts. A single cell constitutes the individual, and this cell must do all the kinds of work of which the plant is capable; it must photosynthesize, assimilate, excrete, grow, and divide to form new cells. There is no setting apart of one kind of cell for vegetative work and another kind for reproduction.

Progress toward higher types of plant life is marked by the formation of rows of cells with a specialized holdfast, as in *Ulothrix* (Fig. 219). Another step forward is marked by the appearance of cell-division in two directions, so that the thallus increases in length and breadth as in *Coleochæte* (Fig. 220).

Differentiation of a thallus into epidermis and spongy parenchyma cells within is well shown in some of the simplest liverworts, such as *Ricciocarpus* (Fig. 189), and filaments, known as rhizoids, serve to absorb water for use in nutrition. Higher liverworts, such as *Marchantia* (Figs. 190–194), show more division of labor among the cells of the thallus, and such liverworts as *Frullania* (Figs. 195, 196) have rhizoids, stems, and two kinds of leaves besides curious pitcher-like appendages.

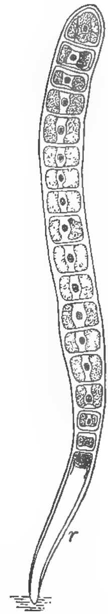


FIG. 219. *Ulothrix*, a Green Alga. (× 300.)

r, rhizoid cell, which serves as a holdfast.

387. Division of Labor among Vascular Plants. — Ascending along the succession of classes until those of the pteridophytes or vascular spore-plants are reached, we find at this point a marked advance in specialization of parts. Ferns, for example, are the first forms represented in the scheme of classification (p. 210) to show the differentiation of the plant body into root,[1] stem, and leaf so familiar among seed-plants. In most ferns the aërial leaves are all nearly alike, but in some genera, as *Onoclea* (Fig. 209), certain leaves of peculiar form are set aside for spore-production. In horsetails and club-mosses the spore-bearing leaves are quite unlike the others, and are often grouped into flower-like clusters (Figs. 211, 213).

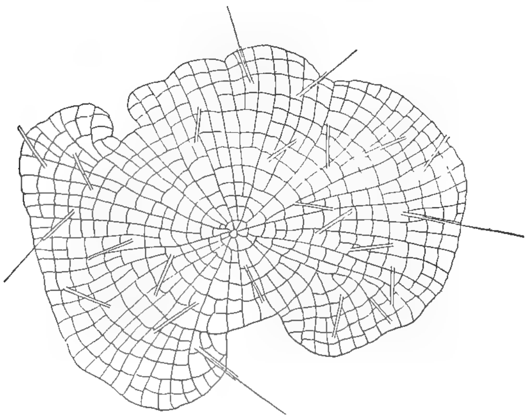


FIG. 220. *Coleochæte*, a Green Alga.

The disk-like thallus is one layer of cells thick.

The fibro-vascular bundles of ferns contain bast-fibers, sieve-tubes, thick-walled wood cells (tracheids), and vessels. The leaves are well provided with stomata.

It is not necessary to go into much detail in regard to the differentiation of parts and division of labor in seed-plants, since these topics have already been treated (Chapters III–XVI). As every one knows, seed-plants have

[1] Rhizoids, though they perform the functions of roots, have not their structure.

usually three sets of vegetative organs, — roots, stems, and leaves. Not infrequently, as in the ivy (Fig. 13), some of the roots perform the work of absorbing soil water, while others serve to aid the plant in climbing. Some plants produce both parasitic roots and ordinary roots for absorption of water from the soil. Stems may in the same plant function as subterranean storehouses of reserve material and as aërial supports for leaves (Fig. 33). In *Myrsiphyllum* (Fig. 37), butcher's broom, and a good many other plants, parts of the stem serve to support in an advantageous position other flattened portions which are specialized for photosynthesis instead of leaves. Ordinary stems may, as in the grapevine and the woodbine, produce special branches (tendrils) which serve as aids in climbing, and the hawthorn, the crab apple, and the honey locust develop dwarf branches in the form of thorns. It is especially worth while to call attention to the fact that in seed-plants the variety of forms and functions of leaves on the same plant has reached a climax. For instance, in such a plant as the lily, the lily-of-the-valley, or the star-of-Bethlehem, we find scale leaves, foliage leaves, bracts, perianth leaves (often of two kinds), and sporophylls (stamens and pistils).

It is difficult or impossible for the mind to grasp the entire set of coöperative activities which go on at every moment during the growing season in any large and highly organized plant. Suppose, for example, that all the living parts of an immense pine tree could be seen in action just before the beginning of its period of flowering. From the tips of the rootlets to the tips of the leaves, a hundred and fifty feet above, many millions of cells are performing the operations of absorbing soil water, conducting it upward, manufacturing plant food by complicated chemical processes, and conducting it to all parts of the plant body to maintain growth in the tissues. Some of the plant food is carried to the rudimentary flowers to form pollen and ovules together with the structures which bear them. Another portion of building material is later carried to the cones of the year before, to maintain growth in the newly fertilized ovules.[1] Still another portion goes to the two-year-old cones to complete their growth. And it must be remembered that each growing and dividing cell is not a simple sac, filled with formless protoplasm, but a very complicated structure with many highly specialized parts.

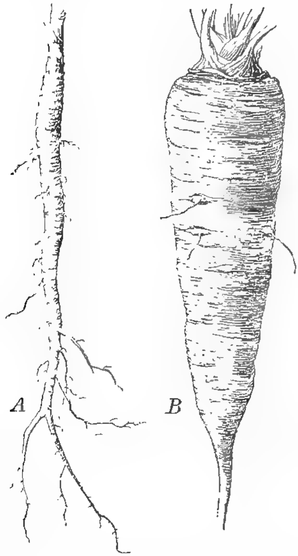


FIG. 221. Effect of Cultivation on Root[2] of Carrot.

A, root of wild carrot, annual or biennial; *B*, root of same species cultivated, biennial. The wild form can be changed in four generations into the cultivated form.

It requires considerable knowledge of chemistry to follow even the principal steps in the transformations which food materials undergo within the plant body. Photosynthesis apparently often results in sugar, which is quickly changed into starch, then back into sugar, for transference to more remote parts of the plant. Here again it is transformed (in root, stem, or fruit) into the starch or oil which constitute the principal reserve material of most plants.

[1] Fertilization in the pine occurs about thirteen months after pollination. See Bergen and Davis' *Principles of Botany*, p. 374.

[2] This is really part root and part hypocotyl.

CHAPTER XXIX

PLANT BREEDING

388. Definition of Plant Breeding. — Plant breeding means the intentional production and perpetuation of new varieties of plants. As a science it is not much more than fifty years old. But some plants have been cultivated for over forty-five centuries,[1] and during all that time attention has been paid to choosing and keeping up desirable varieties of plants.

389. Selection of. Spontaneous Varieties. — As has already been suggested (Sect. 254), plants in a state of nature produce many varieties by ordinary variation, and they may occasionally produce new species by mutation.

Only a very few of all the multitude of spontaneous variations among plants are likely to be valuable to man. An example of this is afforded by the results obtained by the discoverer of the Concord grape. This familiar grape was a seedling from a rather promising wild variety. The grower of the Concord mother vine raised more than 22,000 seedlings from Concord seeds and found only 21 of these worthy of further trial. Not one of these seedlings is now a well-known grape.

Cultivated plants for some reason, perhaps especially because they are highly fed and stimulated to unusually vigorous growth, vary more than wild individuals. Any

[1] See De Candolle's *Origin of Cultivated Plants*, Chapter I.

wheat-field will show many varieties, some better, others poorer than the average wheat plant of the field.

Timothy is the most valuable grass for hay in the majority of the northern states. Some of its most important variations concern such points as these: [1]

(1) Duration, whether annual or perennial.

(2) Power to spread by branches from the base of the stem (*stolons*), some plants producing 10, others 250 heads.

(3) Relation of seed-production to leaf-production: some plants leafy and making good pasture, but bearing little seed.

(4) Yield: single plants sometimes produce less than $\frac{1}{4}$ pound of hay and others over $1\frac{1}{4}$ pounds, or more than five times as much.

390. Selection of Parent Plants. — For thousands of years farmers and gardeners knew of no better way to secure good seed than to save that which was produced by the most promising accidental varieties. But during the nineteenth century growers of several kinds of crops, especially wheat and sugar-beets, hit upon a more complicated and successful plan. Seed from a good many of the most promising plants in a field is saved. This seed is then sown in isolated ground, and the plants raised from it are carefully tended to serve as parents for a new generation of improved plants (Sect. 394). This process carried through several generations, *with careful attention paid to the number and characteristics of all the descendants of each original parent*, furnishes a sure means of improving the race of plants thus treated.

391. Results of Breeding by Selection. — Already volumes have been written describing some of the most im-

[1] See Bailey's *Plant Breeding*, Chapter V, The Macmillan Co., New York.

portant results that have been attained by plant breeders by means of the process of continued selection outlined in Sect. 390. In a general way it may be said that almost any characteristic of a plant or of one of its organs may be made to vary, often in any desired direction. Flowers or fruits may be caused to increase in size many times over; early or late blooming or fruiting may be secured; greater resistance to frost, drought, insects, or parasitic fungi may be developed; a larger per cent of starch, sugar, or oil in given parts of the plant may be obtained at will. Some instances of such modifications are given in succeeding sections of this chapter, but works on farming and horticulture contain thousands of examples of the sort.

392. Sugar-Beet Breeding. — Although we are more familiar in this country with sugar made from the sugar-cane, the larger part of the world's supply is manufactured from sugar-beets. Beets of many varieties have been cultivated since the sixteenth century or earlier. But it was only as late as the middle of the nineteenth century that scientific efforts were made by Louis Vilmorin to increase the percentage of sugar in beets grown for sugar-making. The sweetest roots are usually the heaviest in proportion to their bulk,[1] and therefore Vilmorin tested whole beets or pieces cut from them by placing them in brine strong enough to float all of the roots except those which contained an unusually large per cent of sugar. These selected beets were planted for seed and became the parents of valuable new races.

At present the process of producing beets of the highest value for the manufacture of sugar is a long and

[1] That is, have the highest *specific gravity*.

complicated one, consisting, as usually carried out, of the following steps:

(1) Planting the best seed that can be bought.

(2) Chemically testing average samples of the roots grown from the seed of (1) to see if they are good enough to breed from.

(3) Selecting the best single roots by a chemical test. Less than one-half of one per cent of all the beets tested pass this examination.

(4) Planting the mother roots selected in (3) for the production of what is called "elite seed."

(5) Growing from elite seed small beets which are planted to secure commercial seed.

It requires five years to obtain seed in large quantities from the very few selected roots with which the process of securing improved seed is begun.[1]

Some notion of the thoroughness with which European seed-growers choose their beets may be gathered from the fact that in 1889–1890 one of the most important firms tested 2,782,300 roots, from which it selected only 3043 to be planted for seed production. Constant pains must be taken in maintaining the best possible seed supply, as the quality becomes lowered at once when the seed is grown without special precautions. Two of the most serious ways in which a poor stock of sugar-beets falls short are in the low percentage of sugar and in the production of many worthless annual plants. In central Europe the annual individuals sometimes constitute twenty per cent of the entire crop.

The average yield of sugar from American-grown beets is at present twelve per cent or less. Exceptional beets

[1] See *Yearbook*, United States Department of Agriculture, 1904.

have been found to contain more than double this amount. It would be impossible to produce the roots in large quantities with anywhere near this percentage of sugar, but decided gains may easily be secured and an increase of two per cent in the yield would mean a gain of something like $100,000 per year in the beet-sugar production of the United States.

393. Corn-Breeding. — Indian corn is preëminently an American plant, and several varieties of it were known and valued by the Indians before the coming of the whites. The United States at present produces about four-fifths of the world's corn supply, and the yearly value of the grain alone (excluding that of the leaves and stems used for fodder, ensilage, and so on) amounts to about a billion dollars.

Corn breeding is directed mainly to securing some one of these three kinds of results:

(1) More bushels per acre.

(2) A higher percentage of any of the principal constituents of the grain (starch, proteids, or oil).

(3) Early maturing, to secure a harvest in the northern states where the season is too short for the larger varieties.

The choice of the best seed would certainly increase our corn crop more than ten per cent and add over $100,000,000 per year to its value.

Corn for human food should contain a high per cent of proteids, and this can readily be secured by using seed chosen for the purpose. Corn-oil is coming to be an important article of commerce for food and for manufacturing purposes. The proportion of oil in the grain has been more than doubled by corn-breeders using seed selected for its high oil contents.

Corn of the South and the Middle West, growing sometimes to a height of from fifteen to twenty or more feet, requires nearly or quite six months to mature, but the less prolific two- or three-foot kinds grown in the northern United States and Canada mature in less than three months.

394. Wheat-Breeding. — Wheat is the most important grain for human food in temperate climates, and North America is by far the greatest wheat-producing region in the world. The annual value of the crop of the United States ranges from $250,000,000 to $500,000,000. Wheat has been cultivated for so many thousands of years that its origin is not perfectly known. Scientific wheat-breeding, however, began hardly a century ago and has progressed more in the United States since 1890 than during all our previous history.

Some desirable qualities to be sought for in wheat-breeding are:

(1) Large yield per acre.

(2) Good quality for bread-making, requiring a high per cent of the tenacious *gluten*, the main proteid portion of the grain.

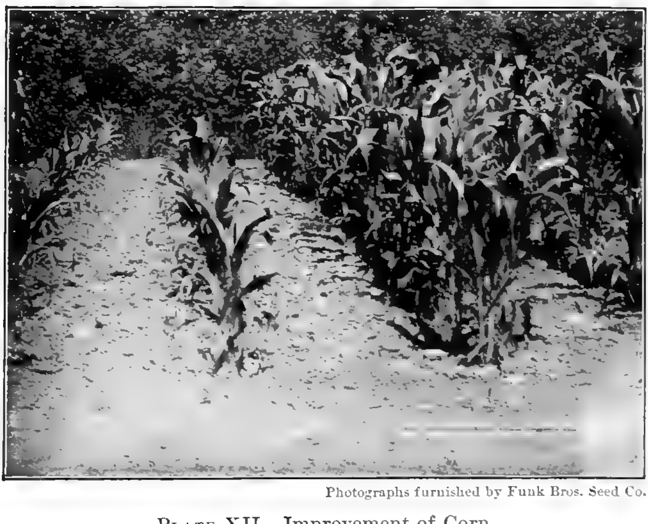
(3) Hardiness, shown in resisting severe winter conditions.

(4) Resistance to rust.

(5) Resistance to drought.

Not all of these qualities can be combined in the highest degree in any one variety, and therefore every region should grow the particular kind of wheat best suited to the local conditions and market.

In order to show how carefully the process of wheat-breeding is managed in our best agricultural experiment



Photographs furnished by Funk Bros. Seed Co.

PLATE XII. Improvement of Corn.

The upper picture shows the effect of kiln-drying seed; the lower picture shows the effect of cross-pollination.

stations, the principal steps of the operation are here given in the barest outline, omitting many most important details.[1]

(1) Ten thousand large, sound kernels of a single good variety of wheat are selected, planted in hills, and each hill numbered. About ninety-five per cent of the poorer plants are rejected as they mature. The heads of each of the chosen plants are put together in an envelope and preserved. When thoroughly dry the product of each plant is weighed, and only a few of the heaviest groups of heads are kept for seed.

(2) The second year about a hundred of the seeds of each mother-plant are planted in a group to which is given a special designating number (hundred-group or *centgener*). Heads of several of the best plants in each hundred-group are reserved for seed. The total produced by each hundred-group is weighed to enable the experimenter to estimate the comparative value of the mother-plants of (1).

(3) The third year the process gone through in the second year is repeated.

(4) The fourth year the same process is repeated.

(5) The fifth year the most promising varieties are planted in small fields in the ordinary way. Those varieties which yield abundantly in the field and turn out well in the milling tests applied to the harvested grain are distributed among farmers for seed-wheat.

A new variety can soon be introduced over an immense territory. It is estimated that in fifteen years from the

[1] See University of Minnesota, Agricultural Experiment Station, *Bulletin No. 62;* and United States Department of Agriculture, Division of Vegetable Physiology and Pathology, *Bulletin No. 29.*

time of planting one seed its descendants might be made to cover more than 5,000,000 acres of wheat-fields.

Wheat-breeding is still making such rapid progress that it is not now possible to say how much the quality and quantity of our wheat crop may yet be improved by the introduction of better varieties. The total number of acres in the United States differs considerably from year to year. It seems likely, as a rule, to exceed 45,000,000 acres. The average yield ranges between ten and fifteen bushels per acre, although it is possible with the most improved seed on the best soils to raise more than forty bushels per acre. Choice of the best seed would undoubtedly increase the average yield to from thirteen to eighteen bushels. It is easy to see how important a gain this would be, even if the price of wheat were no more than seventy cents per bushel.

395. Hybridizing. — Hybridizing, as the term is now generally used, means the production of seed by the action of pollen of one variety or species on the pistil of another variety or species. Nearly always both species must at least belong to the same genus in order to produce seed that will grow, and often different species of the same genus cannot be made to hybridize so as to secure good seed. The offspring produced by hybridization are known as *hybrids*.

It has long been known that hybrid plants are often extraordinarily variable, but the law which governs their characteristics (in many though not in nearly all cases) was not discovered until 1865.[1]

Recently much use has been made of hybridizing in order to set plants to varying, and the most desirable

[1] See Bailey's *Plant Breeding*, Chapter IV, The Macmillan Company.

varieties thus produced have been selected and bred from, as described in Sects. 392, 394.

396. How Hybrids are Artificially Produced. — Hybridizing, or *crossing*, plants is sometimes an easy, sometimes a rather difficult, process. It is simplest in unisexual flowers, for example, in those of Indian corn. Here the "tassel" is a cluster of spikes of staminate flowers and the "ear" is a spike of pistillate flowers, each thread of the "silk" representing a stigma and style attached to an ovary (grain

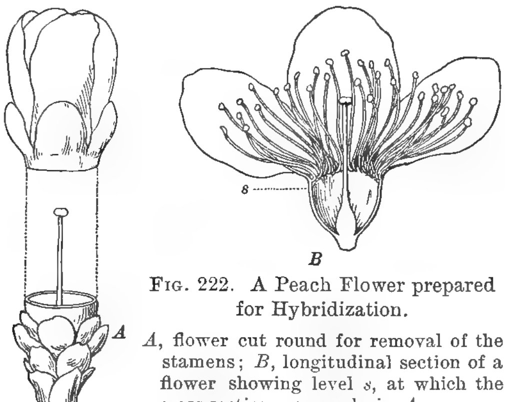


FIG. 222. A Peach Flower prepared for Hybridization.

A, flower cut round for removal of the stamens; *B*, longitudinal section of a flower showing level *s*, at which the cross-section was made in *A*.

of corn). In hybridizing corn it is only necessary to tie a paper bag over the ear before the silk appears, in order to keep off stray pollen, leave it covered until full grown, then remove the bag, dust the silk thoroughly with pollen from tassels of another variety of corn, and keep the ear covered until the silk is entirely withered.

In most cases of hybridizing it is necessary to go through with about the following process:

(1) Select the flower to be pollinated, before it opens or its own pollen is mature. If it is one of a cluster of

flowers, as in the wheat or the apple, remove from the cluster all the flowers that are not to be operated on.

(2) Open the flower and remove the stamens by taking hold of the filaments with fine forceps, or cut away all the stamens at once, as shown in Fig. 222. Then cover the flower or the entire twig with a paper bag until the stigma is mature.

(3) Pollinate the stigma with the desired kind of pollen. This may be done with the finger tip, with a camel's-hair brush, or other implement. It is safer to take pollen from a flower that has been kept covered with a paper bag, to keep off foreign pollen.

(4) Cover the pollinated flower again with a paper bag until the fruit has grown considerably.

397. General Results of Hybridizing. — As already mentioned (Sect. 395), hybrids are likely to be extremely variable. Not only may they differ from either parent, but they may also be unlike each other. The differences include such features as the form, size, and other characteristics of the entire plant or of its roots, stems, leaves, flowers, fruit, and seeds.

It is much easier to perpetuate new varieties in the case of plants propagated by vegetative means than in those grown from seed. If a desirable variety of potato is obtained by hybridizing and then planting seeds from the berries ("potato balls"), the hybrid can be grown with certainty by planting tubers of the new variety. But if a hybrid bean, pea, or wheat plant is produced, only a few of its seeds will "come true to seed"; that is, the offspring of the hybrid seeds will, many of them, be what breeders call "rogues," or undesirable varieties, not closely resembling their hybrid parent. Year after year, for several generations, the garden-plots containing descendants of the new hybrid must be rogued, or gone over plant by plant, in order to destroy all individuals but those of the desired variety. In the case of wheat, after the fourth generation some plants are usually to be found that will "come true to seed."

398. Results of Hybridizing the Grains. — In this country especial attention has been given to hybridizing Indian corn and wheat. Some valuable varieties of corn have already thus been obtained and many more seem likely to

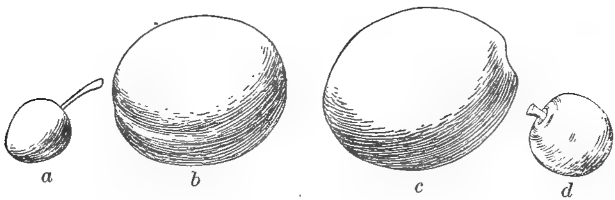


FIG. 223.

a, a stoneless wild plum; *b*, *c*, *d*, fruit of hybrids of *a* with the French prune. (All drawn to the same scale.)

be secured. Hybrid wheats are of importance for use as stocks from which to breed and select. Much time is now spent at the agricultural experiment stations of the great wheat-growing states in hybridizing wheats for breeding purposes.

399. Results of Hybridizing Small Fruits. — The most familiar hybrids among small fruits are grapes. Very likely the Delaware and the Catawba are hybrids, and the Salem, Brighton, and Diamond certainly are. Many varieties are directly or remotely descended from hybrids between the European wine grape and our northern fox grape, two wholly distinct species.

A favorite blackberry, the Wilson Early, is a hybrid between two common wild species, the high blackberry[1] and the dewberry.[2] Among the descendants of hybrids between an almost uneatable species[3] from Siberia and an eatable species[4] from California is a new constant species (not a variety), the Primus blackberry.

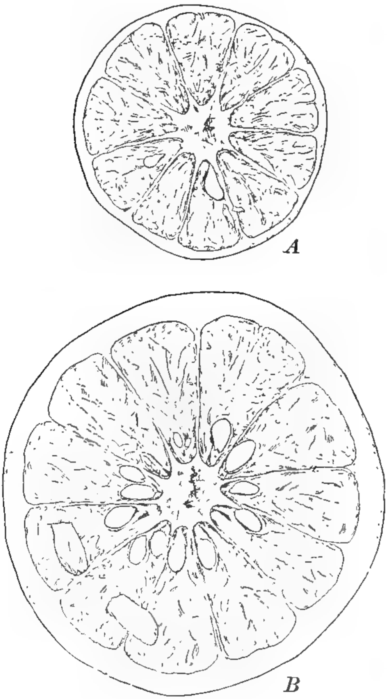


FIG. 224.

A, the tangelo, a hybrid between the tangerine and the grape-fruit; *B*, the grape-fruit (one parent of *A*).

Hybrid plums in the greatest variety have been produced by plant breeders, especially by the well-known Californian experimenter, Luther Burbank. The amount of variation in the offspring of a single hybrid is well shown by Fig. 223. One fruit of great value, the Climax plum, was bred by this experimenter as a hybrid between a bitter, tomato-shaped Chinese plum and a Japanese plum.

400. Results of Hybridizing Citrous Fruits.—Most valuable and interesting work in hybridizing plants of the Orange family has been done by the United States Department of

[1] *Rubus allegheniensis*. [2] *R. villosus*. [3] *R. cratægifolius*. [4] *R. vitifolius*.

Agriculture, under the direction of Dr. H. J. Webber.[1] The hardy trifoliate orange, which resists our winters as far north as Philadelphia, but bears a small, bitter, worthless fruit, was hybridized with the common sweet orange. Three valuable hardy hybrids known as citranges were produced. One of them makes a good substitute for grape-fruit, another for lemons, and the third for rather sour oranges. They may be grown from two hundred to four hundred miles farther north than ordinary oranges.

Another citrous hybrid is that between the tangerine and the grape-fruit. This is called the tangelo (Fig. 224) and has characteristics somewhat intermediate between those of the parent species. It is smaller in size, and the pulp is less bitter and acid than that of the grape-fruit, while the "kid-glove" skin, readily peeled off with the fingers, is like that of the tangerine.

401. Results of Hybridizing Ornamental Flowers. — Some of the most showy flowers of our gardens and greenhouses are hybrids. Among the most important examples are the genera *Canna*, *Amaryllis*, and *Gladiolus*. Orchids, too, have been hybridized to such an extent that a dictionary of hybrid orchids has been prepared.

In most cases of flowers which have been bred and hybridized for many years the process of improvement has been due partly to crossing and partly to selection. It is often impossible to find out how many parent species or varieties have entered into the production of the final hybrid.

402. Summary of Methods and Results. — Successful plant breeding requires a continuous effort to get better plants, either by picking out and growing chance varieties,

[1] See *Yearbook* of the Department of Agriculture, 1904.

or by continued selection first of a set of choice parent plants, then of their best offspring, and so on for several generations.

Hybridizing sometimes (but not nearly always) aids the plant breeder by giving him a large number of marked variations from which to select.

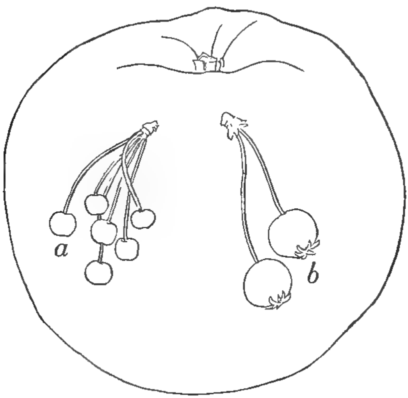


Fig. 225. Effect of Cultivation upon the Size of Apples.

The Bismarck apple, with *a*, the wild Asiatic crab apple (*Pyrus baccata*), and *b*, the European wild apple (*P. malus*). (All half natural size.)

High cultivation together with plant breeding have brought about many astonishing results. Plums three inches long have recently been produced. A hybrid beach-plum bears so abundantly that the twigs are literally hidden by the fruit. The largest cultivated apples are many hundred times the bulk of their remote wild ancestors. A new variety of blackberry plant covers one hundred and fifty square feet of soil and bears a bushel or more of fruit. Most cultivated roots and tubers have been greatly changed from their wild condition, losing in the proportion of woody fiber which they contain and gaining immensely in size (Fig. 221).

One of the most important problems for the plant breeder is how to secure varieties immune to diseases. Two of the most notable achievements of our Department of Agriculture in this direction have been the production of a disease-resisting variety of Sea Island cotton and of watermelons. The soil of valuable cotton plantations had become infested with a fungus (*Fusarium*), which attacked the roots of the plants, plugged the vessels with its hyphæ, and destroyed almost the entire crop. In consequence of this many planters gave up cotton-growing. Observation showed that often in a field where nearly all the plants were killed here and there an individual survived, blossomed, and ripened its capsules. For four years plants were bred from the seeds of these resistant individuals until a variety was secured which withstood the attacks of the fungus and made it possible to resume cotton-growing on the abandoned plantations.

Extensive areas in the South, once devoted to the culture of watermelons, became so infected by a fungus (*Fusarium*) that melon-growing was no longer possible. The destruction was so complete that no process of selection could be adopted, as in the case of the cotton. It was, however, found that the roots of the so-called "citron," a plant of the watermelon genus, were not attacked by the fungus. Watermelons were hybridized with "citrons," and about a thousand varieties were grown from the seeds thus obtained. Many of these proved resistant, but only one was found to be resistant and at the same time desirable in most other respects. This one variety is now grown with perfect success on any fungus-infected soil.

CHAPTER XXX

SOME USEFUL PLANTS

403. Definition of Economic Botany; Subdivisions.— *Economic botany* treats of the uses of plants to man. Beginners in botany can only afford time for a brief summary of the principal uses of a few of the most important plants.

Some of the principal classes of plant products valuable to the human race are these:

(1) Foods for man.

(2) Medicinal plants and their products.

(3) Foods for domestic animals.

(4) Fertilizers of vegetable origin.

(5) Tanning materials, dyes, varnishes, and miscellaneous products of vegetable origin.

(6) Plant fibers, hairs, and similar products.

(7) Plants cultivated for ornament.

(8)[1] Timber and cabinet woods.

(9)[1] Fuel.

(1) FOODS FOR MAN

404. *The grains* constitute the main part of our food supply, from vegetable sources, and are especially valuable on account of their concentrated character and their keeping qualities. The principal grains are wheat, oats, rye, barley, rice, and Indian corn. They are all the fruits of

[1] These two classes are for convenience treated in Chapter XXXI.

certain grasses known as *cereals*, and on account of this and other facts the Grass family is the most important family of plants from the economic point of view. Wheat is the most highly prized of the grains on account of its high food value, digestibility, and fitness for bread-making. The United States is the leading wheat- and corn-growing country, producing more than one-fourth of the world's crop of the former grain and four-fifths of the latter.

Rice is extensively grown in South Carolina and the Gulf States, but the world's principal supply comes from Asia. It differs from the other cereals in requiring to be cultivated on land that can be flooded during part of the year. For this reason rice culture is often attended by malaria.

405. Leguminous Seeds. — The Pea family (*Leguminosæ*) comprises about seven thousand species, and many seeds which form a considerable part of human food are derived from this family. The ones most generally used in our own country are peas and beans. Whether eaten in an unripe condition or after becoming mature and dry, they form a highly valuable source of proteid food. Peanuts are the seeds of a leguminous plant largely grown in the South Atlantic States and elsewhere. Our crop of these is largely consumed at home, but also forms a considerable article of export. Other leguminous seeds much used as articles of food in Europe and elsewhere, although not as yet largely consumed in the United States, are broad beans or Windsor beans, chick peas, and lentils.

406. Other Seeds. — A great number of seeds which do not come from plants of the Grass family or the Pea family are used as human food. The most important tropical one is the cocoanut (Fig. 226), a drupe containing an enormous seed with oily endosperm, eaten in its natural condition, and also used in the preparation of many well-known dishes and in confectionery.

Chocolate, so well known as a food, a flavoring, and as a beverage, is made from the ground or crushed seeds of the cacao tree (Fig. 227), cultivated in many tropical countries, originally a native of Mexico. Cocoa is merely chocolate deprived of a large part of its oily material.

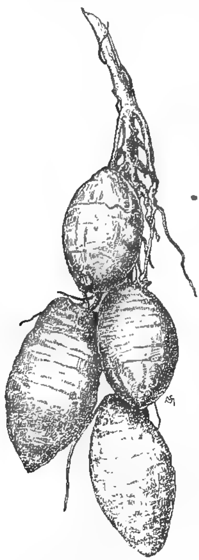


Fig. 226. A Cluster of Cocoanuts. (Much reduced.)

Coffee, which has little value as a food, but is most widely used as a stimulating beverage, is made from the seeds of a small tree, a native of the mountains of eastern Africa, much cultivated in tropical countries. The seeds are borne in red berries abundantly clustered in the axils of the leaves (Fig. 228).

Many edible nuts of temperate climates are furnished by three families of trees. The Walnut family furnishes the so-called English walnuts, black walnuts, butternuts, pecans, and hickory nuts; the Birch family furnishes hazelnuts and filberts; and the Beech family furnishes beechnuts and chestnuts.

From the Rose family come almonds, which are drupes, like a peach, but with the ripened ovary-wall fibrous rather than fleshy.

From a tropical family related to the mangroves and the myrtles are obtained the well-known Brazil nuts.

407. Pulpy Fruits. — The most important tropical fruit with fleshy pulp is the date (botanically speaking, a berry).

FIG. 227. A Cacao Tree.

The flowers (and therefore the fruits) spring directly from the main stem and the larger branches.

This is one of the most considerable articles of food for the peoples of northern Africa and northwestern Asia. The date-palm is very productive, bearing for a century or more, and when well grown producing from one hundred to five hundred pounds of fruit a year. Successful attempts are now under way to introduce date culture into some of the hottest portions of the United States, and it is likely to be an important industry in central Arizona, the Colorado Desert in California, and several other arid or semi-arid areas.

Fig. 228. A Coffee Twig, with Berries. (Reduced.)

The Pineapple family furnishes only one valuable fruit, the pineapple, grown especially in Florida, the West Indies, the Azores, and Hawaii.

The Banana family furnishes, in the shape of bananas, the main food of multitudes of the poorer inhabitants of the tropics. The plant is herbaceous, though it sometimes reaches a height of forty feet, with leaves as much as ten feet long (Plate XIII). The familiar fruit (technically, a berry) has by long cultivation become seedless. It has a much higher nutritive value than most fruits and is rapidly coming into favor among us, the annual imports into the United States having increased from about 500,000 bunches in 1872 to some 40,000,000 bunches at present. A few bananas are grown in southern Florida and the delta portion of the Mississippi, but the main product comes from the West Indies and Central America.

Photograph furnished by the United Fruit Co.

PLATE XIII. Fruiting Banana Plants.

The Mulberry family produces the breadfruit, which is the chief means of subsistence of many islanders of the South Pacific. The only two fruits of the family familiar to us are the mulberry and the fig. Our supply of figs is mainly derived from imports of the dried fruit from Asia Minor, but fig culture is now well established in California.

The Saxifrage family and the Rose family produce many of our berries, properly so called, and a number of other kinds of fruits commonly though incorrectly known as berries. To the former family belong currants and gooseberries, to the latter, quinces, pears, apples, strawberries, blackberries, raspberries, plums, cherries, peaches, apricots, and nectarines.

Strawberry-growing in the United States was an industry of no importance until after 1840, but has now become extensive. The crop is a very profitable one, as under the most favorable circumstances more than four hundred bushels have been raised on an acre. The market was formerly only for a few weeks of the year, but now lasts over as much as five months, beginning in February with berries from the Gulf States and ending in July with Canadian berries.

Apples form the leading fruit crop of North America, as the product of a good year amounts to about 100,000,000 barrels, for the United States and Canada. They succeed well in most of the more northerly states, and about a thousand varieties are grown.

The Rue family gives us the citrous fruits, including ordinary oranges, tangerines and mandarins, lemons, and grape-fruit. Oranges are of Asiatic origin and have long been cultivated in hot and warm temperate climates. The first sweet oranges grown in what is now United States territory were brought to California by the Franciscans about 1769. Orange production in this country was for a time most extensively carried on in Florida, but severe frosts there cut off many orchards, and now the greater part of the crop (over 10,000,000 boxes) comes from California. The famous Washington navel orange, nearly or quite seedless, so largely grown in California, originated from chance seedlings. These were found growing wild in a swamp along the Amazon, and were brought from Bahia, Brazil, to the United States Department of Agriculture in the early seventies.

The Grape or Vine family contains only one genus, the grape, which is of economic importance, but it is one of the oldest cultivated plants. The grapes of the European type, such as the Malaga, Black Hamburg, Muscat, and the Tokay variety so extensively grown in California, are solid-meated and are all descendants of a single wild species. American varieties, such as the Concord, Delaware, Isabella, Niagara, and many other familiar kinds, with soft pulp readily separated from the skin, are descended from wild American species (Sect. 389). Grape culture is carried on most extensively in California, where the fruit is grown for table use, for wine-making, and for preservation by drying into raisins.

The Heath family produces several highly valued species of berries. The most important are cranberries, blueberries, and huckleberries. Cranberries of the ordinary large species are borne by a delicate, trailing, woody plant, which flourishes particularly in peat-bogs all the way from North Carolina to Minnesota and throughout a large part of Canada. Cranberry culture is extensively carried on in

Massachusetts, New Jersey, and Wisconsin, and there is a large yield from uncultivated swamps.

Blueberries and huckleberries belong to two different genera, but have considerable superficial resemblance. The former berry, borne on bushes of several species, from six inches to ten feet in height, is the more valuable and is gathered for the market over wide areas of the northern United States and Canada. The "heaths" or "blueberry barrens" on which the bushes grow in great abundance are often carefully reserved and the berries systematically picked for shipment.

The Olive family furnishes a very important fruit, the olive, which is considerably utilized by pickling in salt water and serving as a relish. Olive-oil, expressed from the fruit, is a most valuable product and is not only used as a food throughout most civilized countries, particularly in the Mediterranean region, but is also utilized for many mechanical purposes and for soap-making.

The Nightshade family, which contains many poisonous plants, yields several edible fruits. These are true berries, though they are not commonly so called. The principal ones are the ground-cherry or strawberry-tomato (*Physalis*), of which wild and cultivated species are used in making preserves, the red pepper (*Capsicum*),[1] the egg-plant, and the tomato. The tomato was introduced into cultivation from tropical America as a curious ornamental plant for the garden. Its fruit was originally small, two-celled, and watery, but by cultivation has become large, fleshy, and several-celled. It is extensively grown for the market, and large canning establishments in several states handle the product of special tomato farms.

[1] This is not a pulpy fruit, but is for convenience mentioned here.

The Gourd family furnishes many edible fruits. Of these the pumpkin and the summer squashes are varieties of the same species, and the large winter squashes belong to another species of the genus *Cucurbita*, probably of American origin. The watermelon belongs to a genus (*Citrullus*) of Asiatic origin. The muskmelons, nutmeg-melons and other varieties, and the cucumber belong to another genus (*Cucumis*), and most of our varieties are descended from two southern Asiatic species.

408. Edible Leaves, Stems, and Roots. — Not many kinds of food of prime importance consist of the leaves or aërial stems of plants. The Lily family yields asparagus; the Pigweed family, spinach; the Mustard family, water-cress, cabbage, cauliflower, and Brussels sprouts; the Parsley family, celery; and the *Compositæ*, lettuce and globe artichokes (*Cynara*).

Since the underground portions of the plant often store up much reserve material (Sect. 76), it is evident that bulbs, rootstocks, tubers, and roots must often be of value as food. Only a few of the most important of these are here mentioned. The Lily family yields onions; the Yam family, yams; the Pigweed family, beets; the Mustard family, turnips and radishes; the Parsley family, carrots and parsnips; the Morning-glory family, sweet potatoes; the Nightshade family, potatoes; and the *Compositæ*, salsify and Jerusalem artichokes (*Helianthus*).

The potato crop is so important that a few words may here be said about it. The annual yield for the United States is usually over 200,000,000 bushels. Introduced into cultivation from Peru, potatoes soon became one of the principal foods of the cooler parts of the world. They are particularly well suited for cultivation in regions where the summer is short, cool, and moist, so that wheat or Indian corn would not mature. Many varieties have been produced by selection from seedling plants, and under the influence of long cultivation the size of the tubers has greatly increased and the tendency to produce seed in the berries (commonly known as "potato balls") has diminished.

409. Tea. — Tea cannot properly be called a food, since if drunk without cream or sugar it supplies only traces of nourishment. It is, rather, a mild stimulant, but is so commonly taken with food that it may be mentioned with food products. The tea-plant is a shrub belonging to the family *Theaceæ*, to which the familiar camellia of the greenhouses also belongs. It is thought to occur in a wild state in eastern India and has for ages been cultivated in India, China, and Japan. The tea-leaves are picked several times during the season and dried for packing and shipment. The various colors and grades of tea depend mainly on the maturity of the leaves and the amount of fermentation which they are allowed to undergo before drying.

410. Starch and Sugar. — Starch can be obtained on a large scale from any of the grains by grinding them into flour or meal, treating this with sulphurous acid or alkaline solutions in order to get rid of the sticky proteid material which holds the starch grains together, and then washing the starch out clean from the bran and other impurities with which it is mixed. Corn-starch, for use as food, is extensively manufactured in this country.

Sago is the purified starchy pith of sago-palms, small trees found in Siam and the Malayan Islands. It is also made from palm-like plants (cycads), natives of the West Indies.

Tapioca consists mainly of starch. It is made from the grated or ground-up roots of the cassava plant (Fig. 229), a native of Brazil, now cultivated in many of the warmer parts of the world, including our own Gulf States. The clustered roots may together weigh as much as thirty pounds, and the product per acre is therefore very large. The juice of one species is acrid and poisonous, but is

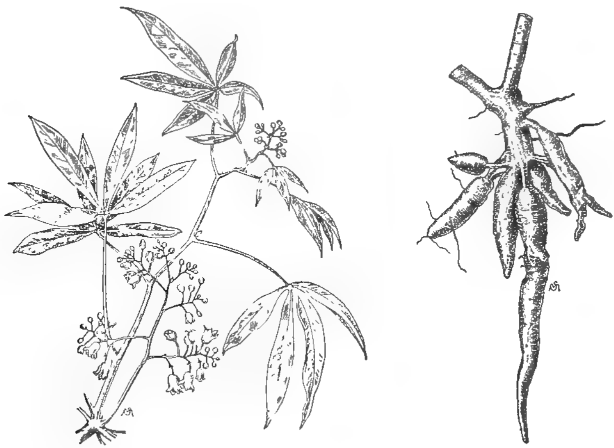


FIG. 229. A Twig and Cluster of Roots of Cassava. (Much reduced.)

soon removed by heating or merely drying the ground roots, which form an extremely valuable food for horses, cattle, and hogs.

Arrowroot is a highly digestible kind of starch obtained from the rootstocks of several kinds of tropical plants of the Arrowroot family (*Marantaceæ*) and other families.

Sugar is manufactured from the juice of the sugar-cane (Fig. 230), a grass growing to the height of ten feet or more, cultivated in Louisiana, the West Indies, Java, and the Hawaiian Islands. It is also still more largely manufactured from the juice of the sugar-beet (Sect. 392), both in Europe and in our own country.

A small amount of sugar of delicious flavor is made in various parts of the United States from the sap of the sugar maple.

(2) MEDICINAL PLANTS AND THEIR PRODUCTS

411. For thousands of years nearly all the most important medicinal substances were parts of plants or simple infusions ("teas") or tinctures made from plants. During the nineteenth century chemical compounds, such as the alkaloids, of which quinia and morphia are familiar examples, took the place, to a considerable extent, of cruder preparations, such as wine of Peruvian bark and laudanum, made from the same plant material. More recently many of the coal-tar products have come into general use as remedies. But a little examination of the contents of any well-stocked pharmacy will serve to show how dependent we still are on the curative action of plants for treating diseases. Sometimes the dried root, stem, or leaf is sold for medicinal use, as in the case of marshmallow root, quassia wood, sage leaves. Often the

FIG. 230. Flower Cluster and Leaves of Sugar-Cane. (Much reduced.)

fruit, as in the so-called cardamom seeds, or the seed, as in mustard and flaxseed, is the medicinal part of the plant. Occasionally some secretion or excretion of the plant is of remedial value, as in the case of Canada balsam and gum arabic. Nearly seventy families of angiosperms are represented in the official list of medical plants.[1] Some families have medicinal properties quite generally distributed throughout their species, while others have only one or a few species with curative properties.

Medical botany is a subject on which many special works have been written, but this brief summing-up is all that can be given here.

(3) FOODS FOR DOMESTIC ANIMALS

412. Some of the grains, especially corn, oats, and barley, are largely fed to domestic animals. Of the roots and tubers which are used for human food, beets, carrots, turnips, and potatoes are considerably fed to cattle, sheep, and hogs in some parts of the country.

Many of the grasses constitute pasture for grazing animals or are made into hay. Throughout a large part of the United States the hay crop is one of the most important of all to the farmer, and its annual value usually amounts to over $500,000,000. Alfalfa, several clovers, soy-beans, and cow-peas are some of the principal plants of the Pea family useful as horse and cattle food.

Forage is prepared from such plants as red clover, alfalfa, and others, cut green and fed to horses and cattle. Cornstalks, when nearly mature, are largely used in this way, and the stems and leaves cut up and allowed to ferment are

[1] The *United States Pharmacopœia*.

largely used as a winter food for cattle under the name of *ensilage*. Much use is also made of dried corn stems, with the leaves, variously known as "corn fodder" and *stover*.

The residues left after certain manufacturing processes are of great value as food for horses, cattle, sheep, or hogs. Among these are linseed meal and cotton-seed meal from which all the oil possible has been extracted by pressure. Brewers' grains and distillery swill, the latter consisting of a sort of thin sour gruel of corn meal from which all the alcohol has been distilled, may be fed in moderate quantity to cattle and hogs without ill effects, and are used in the fresh condition and dried for shipment. The refuse from the manufacture of beet-sugar is also considerably utilized, both moist and after drying.

(4) FERTILIZERS OF VEGETABLE ORIGIN

413. Crops impoverish the soil by removing from it the raw materials for the manufacture of plant food. The most valuable of these are nitrates and potassium compounds. It is evident that the fertility of the soil can best be maintained by restoring to it all parts of the plant not to be sold at a profit. For instance, if beans are grown upon a piece of ground, the stems and leaves, after the crop has been gathered, should in some way be restored to the soil and plowed under, — not burned, since burning would destroy much available nitrogen. Cotton-seed meal is much used as a fertilizer and restores to the soil most of the valuable material taken from it by the growth of the cotton crop.

Wood-ashes is a useful fertilizer, from the amount of potassium salts which it contains.

Seaweeds are considerably employed for fertilizing purposes along some parts of the New England coast.

It has long been known that poor soils may be benefited by plowing under certain crops grown upon them. Most of the plants employed in this way belong to the Pea family, and clovers and alfalfa are among the species

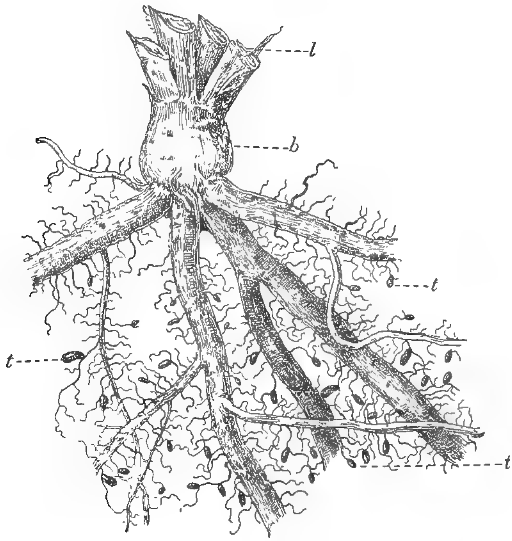


FIG. 231. Roots of Red Clover with Tubercles.

l, sections of ascending branches; *b*, enlarged base of stem; *t*, root-tubercles containing bacteria.

commonly plowed under. It has only recently been ascertained that the value of leguminous plants for this purpose is chiefly due to the fact that they bear upon the roots tubercles containing bacteria (Fig. 231) which can take free nitrogen from the air and deliver it to the host-plant (clover, etc.) in a form which can at once be utilized by the latter. These "nitrogen-fixing bacteria" therefore afford an unlimited supply of nitrogen available for the nutrition of the higher plants almost without expense to the farmer and gardener.

(5) TANNING MATERIALS, DYES, VARNISHES, AND MISCELLANEOUS PRODUCTS OF VEGETABLE ORIGIN

414. Many of the substances mentioned under this head are fully discussed in treatises on the chemistry of various manufacturing industries. All that can be done in this place is to give a few examples of plant products used in manufacturing processes.

Vegetable dyes are no longer nearly as important as they were before the discovery of aniline colors. Antique Oriental rugs and other articles, however, show well how much superior are the soft shades produced by dyes of vegetable origin. A large number of dyestuffs are obtained from tropical or sub-tropical plants of the Pea family; among these are Brazil wood, logwood, camwood, and indigo.

Varnishes usually consist of some kind of rosin dissolved in alcohol, oil of turpentine, or linseed oil. Among the most valuable varnishes are shellac (from trees of the Mulberry family), copal (Pea family), and Japanese lacquer (Sumach family).

Common rosin and turpentine are made from the sap of pine trees, particularly our longleaf southern pine. Deep cuts are made through the bark into the wood, and from these a pitchy liquid slowly flows. By distilling, this is separated into a nearly colorless liquid, oil of turpentine, commonly called "spirits" of turpentine, and the familiar rosin used by tinners. The liquid evaporates and is condensed, while the rosin is left behind in the still.

Tanning is mainly done by the use of infusions of various kinds of astringent bark. In this country the bark of the black oak and the Spanish oak is largely used. Hemlock bark is also employed and is often treated in the forests where the trees are felled, to obtain a thick extract, which is shipped in barrels to the tanneries. Twigs and leaves of American and Sicilian sumach are used in tanning some of the thinner and finer kinds of skins, and imported extracts made from several tropical trees are employed in some tanneries.

India rubber is made from the sap of several trees and lianas found in the tropical regions of both hemispheres, and gutta-percha is yielded by trees of the tropical Star-apple family, which also produces many edible fruits.

(6) PLANT FIBERS, HAIRS, AND SIMILAR PRODUCTS

415. Many of the most valuable plant fibers, such as flax and hemp, are manufactured from the hard bast, others, as cotton, are composed of plant-hairs. Sometimes the whole stem or leaf of the plant is braided into a fabric, as in the case of straw hats and similar articles.

Sedges (*Cyperus*) are woven into East Indian and Chinese mattings.

Grasses of several genera (including some of the grains) are braided into hats, mats, baskets, and other articles. Straw and the coarse, tough *esparto* grass from Spain and North Africa are used in paper-making.

Palms yield abundant supplies of fiber, and that of the husk of the cocoanut is used to make rope, mats, and brushes.

The Banana family yields the well-known manila fiber which is woven into very delicate fabrics, while the coarser kinds make the tough manila rope.

The Mulberry family contains the paper mulberry tree, from the bark of which is made Japanese paper, and the hemp plant, of the greatest importance in the manufacture of rope and twine.

The Linden family, the Mallow family, and the Silk-cotton family, all closely related, are the source of many valuable hairs and other fibers. Of these cotton, belonging to the Mallow family, is by far the most important. The product which is spun into thread and woven into so many kinds of fabrics consists of the hairs which thickly clothe the seeds of the plant. Cotton is cultivated in India, Egypt, and our own Gulf States, Georgia and South Carolina. The Sea Island cotton, grown on islands off the coast of South Carolina, is the most valuable variety anywhere produced, on account of its length and fineness. Our annual cotton crop amounts to from 9,000,000 to 13,000,000 bales of 500 pounds each and is of a value ranging from over $300,000,000 to nearly $600,000,000. The stems of the plant may be utilized for paper-making, and the seeds afford a valuable meal used as a food for cattle and a fertilizer.

Paper-making consumes immense quantities of vegetable fibers of various kinds. Linen and cotton rags, old hemp and manila rope, jute and even straw, are used in the manufacture of various grades of paper. Several kinds of the softer woods, especially spruce and poplar, are very largely employed in making some of the poorer kinds of white paper, such as are used for printing newspapers.

(7) PLANTS CULTIVATED FOR ORNAMENT

416. Many thousand species of ornamental plants are cultivated in our parks, gardens, and greenhouses.

As regards size and duration, these plants may be classed into trees, shrubs and undershrubs, herbaceous perennials, and annuals. A good many evergreen conifers are planted for shade trees, but the number of hard-wood trees is still larger. Some of the most beautiful species, like the great-flowered magnolia, are not hardy in the northern United States, and many considerations, such as power to resist cold, drought, insect enemies, wind storms, and other destructive agencies, all have to be taken into account in making choice of shade trees for any given locality.

Shrubs and undershrubs are cultivated for their foliage, as the box and privet; for their flowers, as *Forsythia* and lilac; for their fruit, as mountain ash.

With the exception of foliage plants, as some cannas, *Coleus*, and a small number of other common species, most herbaceous plants are grown for their flowers.

By far the larger part of our cultivated ornamental plants are natives of other countries, and some common weeds, like bouncing Bet (*Saponaria*) and blueweed (*Echium*), have become introduced by cultivation. Tropical plants are of course usually cultivated only in greenhouses, and the list of these is a very long one, including among the rarest and most beautiful species many of the Orchis family. Of our native species common in cultivation perhaps the most beautiful shrubs are several azaleas and *Rhododendrons* of the Heath family, and the most showy late summer- and autumn-blooming plants are several *Compositæ*, such as *Rudbeckia*, *Coreopsis*, and *Helianthus* (the sunflowers).

CHAPTER XXXI

TIMBER; FORESTRY

417. Coniferous Woods. — Our native woods[1] are best classified into the two principal groups of soft (or coniferous) and hard woods.[2] The needle-leaved or coniferous trees of the country furnish more than three-quarters of our timber supply. Of these trees the pines are the most important, and there are at least eight species of them which may be ranked as sources of timber. White pine (*Pinus Strobus*) is the softest and most workable of all, while long-leaf pine (*P. palustris*, Fig. 232) is the hardest, strongest, and most durable when exposed to the weather or in the soil.

Of coniferous woods other than pines some of those most in use are: in the East, two species of spruce (*Picea*) and hemlock (*Tsuga*); in the South, the American or bald cypress (*Taxodium*); in the West, species of spruce (*Picea*), the smaller redwood (*Sequoia*), and the "Douglas fir" (*Pseudotsuga*).

The structure of coniferous wood, as seen for example on the end of a beam cut off squarely, or on a new lead pencil, is in one respect less complex than that of most

[1] See United States Department of Agriculture, Division of Forestry, *Bulletin No. 10*, "Timber."

[2] Some of the needle-leaved or coniferous trees, such as the larch and the yew, have rather hard wood, and some broad-leaved trees, such as willows, poplars, tulip-trees, and buckeyes, have soft wood, but people who deal in timber usually speak of the two general classes as explained above.

hard woods. There are no ducts, and the main bulk of the wood is composed of rather long closed tubes (*tracheids*) which taper to a point at each end. The rings plainly seen on the cross-section of some kinds of coniferous timber are

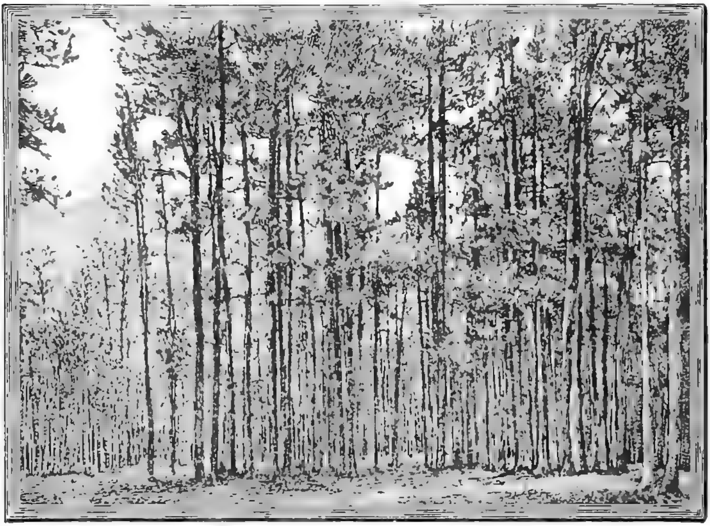


FIG. 232. Forest of Hard or Yellow Pine (*Pinus palustris*) on Southern Coastal Plain of the United States.

(After Frye.)

due to the difference in diameter of the tracheids formed in early spring and later on (Fig. 233).

418. Hard Woods. — North America furnishes more species of trees valuable for hard-wood timber than any other region of similar area with a temperate climate. About eighty kinds are of economic importance, and of these six or eight are oaks, classed for commercial purposes as white and red or black oaks. White oak is stronger than the red kinds but has not so coarse a grain, so that for cabinet-making the red oaks are more ornamental and often in "quartered" cut lumber (sawed tangentially) are very showy. More than half of our supply of hard-wood timber is furnished by the oaks.

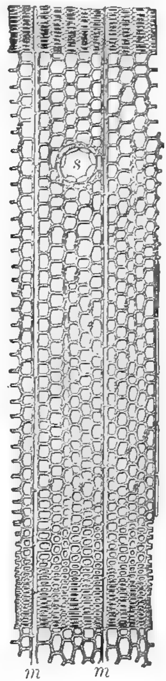


Fig. 233. Cross-Section of Fir Wood.

s, a rosin passage; *m*, medullary rays. (Much magnified.)

Tulip-wood, from the tulip-tree (*Liriodendron*), is next in importance to the various kinds of oak, among the woods of broad-leaved trees. It is variously known as yellow poplar and white wood and grows in abundance in the Ohio Basin and southward, but does not, like oak, form separate forests. The wood is very soft and workable and has largely taken the place of white pine for the inside finish of houses and in the manufacture of woodenware.

Ash, beech, birch, chestnut, elm, maple, red gum, and sycamore are some of the most important hard woods for general purposes besides those already mentioned. For especial purposes certain woods not of the greatest value for all-round construction are highly prized, as hickory for ax and other tool handles and for carriage spokes; beech for shoemakers' lasts, saw handles, and carpenters' planes; persimmon for wood turning and shoe lasts; black locust for posts and railroad ties (on account of its durability in the ground).

For cabinet work the most valued of our hard woods are black walnut, cherry, birch, and a good many species of oak and of ash. White walnut, red or sweet gum (*Liquidambar*), sycamore, and holly are also used.

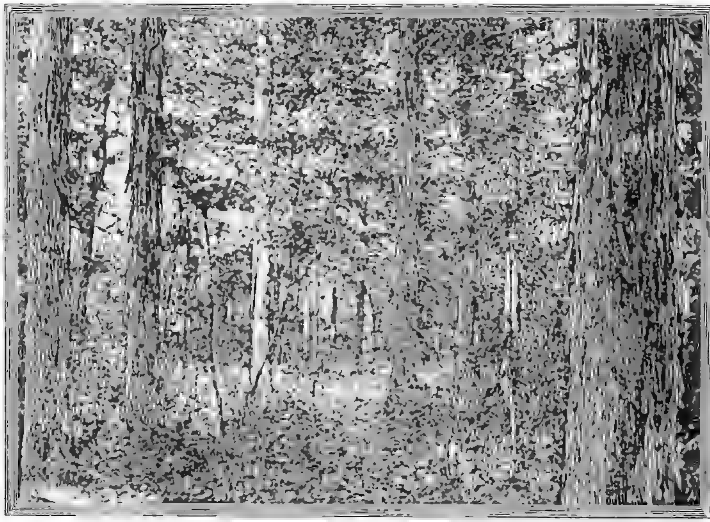


FIG. 234. Hickory (Hard-Wood) Forest near Southern End of Appalachian Highlands.

(After Frye.)

In structure the broad-leaved woods may be classed into two groups, — the *ring-porous* and the *diffuse-porous* kinds.

In the former most of the conspicuous ducts (the cut-off ends of which appear as pores in the cross-section) are found in the spring wood. In the latter the ducts are scattered somewhat generally throughout the wood of the

Fig. 235. Spreading Habit of a Tree growing in the Open.

Trees standing by themselves, like this American elm, are of use for firewood, but do not furnish much valuable lumber.

spring and summer growth (Fig. 236). Among the commonest and most typical of the ring-porous woods are ash and oak, and of the diffuse-porous ones, birch and maple.

419. Wood as Fuel. — Although coal (Sect. 375) is the fuel of the world's great industries, yet there are large areas throughout which wood is still the principal fuel. All kinds of wood can be burned, but for certain purposes those kinds are preferred which make an abundant flame or which leave solid beds of glowing coals. In general the heating effect of well-dried wood when burned is nearly

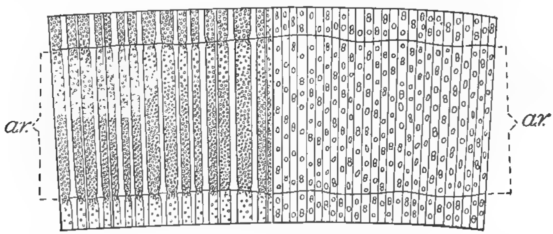


FIG. 236. Diffuse-Porous Woods. (Somewhat magnified.)
ar, annual rings.

proportional to its weight per cubic foot. The fuel value per cord is therefore dependent on the weight per cord, and the heaviest woods, such as hickory, most of the oaks, hackberry, and some kinds of ash, are the best for burning. For certain purposes, where a concentrated smokeless fuel which lights easily and does not readily go out is required, charcoal is employed. Generally the heaviest woods make a dense charcoal of great heating power.

420. Forestry. — Forestry as a science deals with the factors which concern the occurrence and growth of forests. Forestry as an art deals with the rules of forest management and is directed toward the maintenance of our existing forests in the most productive condition possible and the establishment of new areas of woodland. Forestry has long received much attention in most parts of central and northern Europe, but among us it is only beginning to assert itself as a subject which must be taken into account to insure continued national prosperity. Coming to a heavily wooded country, our early colonists felt that the woods were their natural enemies, hindrances to farming operations, and lurking places for Indians and wild beasts. The forests were rapidly cut down and burned, and it did not occur to most people until this wholesale destruction had gone on for more than a century and a half that our timber lands formed one of the most important portions of our natural resources.

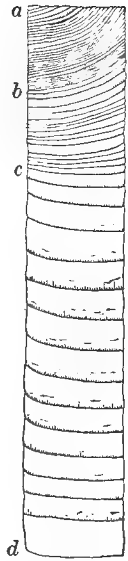


FIG. 237. Effect of thinning out on Forest Growth.

The figure represents part of the cross-section of a fir tree, about half natural size; the early growth from *a* to *b* was very slow, as the young tree was shaded by spruces; from *b* to *c* the growth was more rapid, as part of the spruces were blown down by a storm in 1871; from *c* to *d* the growth was still more rapid, as the remaining spruces were destroyed by a storm in 1885–1886.

421. Forest Management. — This is too technical a subject to be treated in any detail in a high-school botany, though there is much of the elementary part of it which is quite within the reach of high-school pupils.[1] A few of the main principles are as follows:

(1) Only mature trees should be cut, unless saplings are needed for special

[1] See Roth's *First Book of Forestry*, Ginn & Company.

uses, and the younger trees should not be injured by letting those which are felled break them down as they fall. Many kinds of woodland may be kept for centuries in a condition of uninterrupted productiveness by thinning out only the largest trees.

(2) Forest fires must be prevented, especially in coniferous forests. This may be done by preventing fires from being kindled for any purpose in large tracts of woodland, and in some cases by cutting up woodlands, by means of roads, into wood lots of moderate size. In dry, hot weather constant inspection is needed to keep from spreading any fires which may occur.

(3) Parasitic fungi and those which promptly seize upon newly felled wood should be destroyed by burning both them and the infected wood, taking suitable precautions to prevent the fire from spreading.

(4) Destructive insects, such as the various wood-boring and leaf-eating species, should, if possible, be destroyed. In many cases the expense of killing the insect pests of forests would be too great to be undertaken on a large scale. But it is thought that sometimes this may be accomplished by introducing into the region affected parasitic or other insects which will destroy the species injurious to trees.[1] Attempts are now being made to get rid in this way of the gypsy moth, whose caterpillars strip both coniferous and deciduous trees until the woods attacked by them look as if swept by fire. The importance of taking prompt action upon the appearance of a new insect-enemy of trees is well illustrated by the case of the gypsy moth

[1] A scale insect once very destructive in Californian orange orchards was successfully controlled by the introduction of an Australian lady-beetle which fed on the scale insects.

above mentioned. It was introduced from Europe in 1869 by a scientist living at Medford, near Boston, Massachusetts, in the course of some experiments on silk-producing insects. It soon escaped into his garden, but could easily have been exterminated if prompt measures had been taken to secure every patch of eggs deposited on trees in the vicinity. This was not done, and the insects propagated themselves, until after twenty years they began to be troublesome. In 1890 efforts to extirpate the moth were begun on a large scale, but though from 1890 to 1897 more than $865,000 were expended by the state in destroying the moth, it still remained a serious enemy to the trees over a region some two hundred square miles in area. By the aid of United States government funds the insect is now held in check, but no one can say when it will be exterminated.

(5) Sheep and cattle must not be pastured in woods in which they can seriously injure the value of the timber product. Cattle do not usually do much damage in forests which consist mainly of mature trees. They destroy some young broad-leaved trees by browsing, but do not molest young conifers. Sheep injure young seedling trees by browsing, and they do much more serious damage, particularly on hillsides and mountains, by grazing the grass too closely and cutting the turf to pieces with their sharp hoofs, so that it is dried up by the sun and washed away by heavy rains. In the Rocky Mountain region and along the Pacific slope in this country and over great tracts in southern Europe, valuable forest land has been converted into worthless rock and gravel-covered treeless slopes as a result of sheep-pasturing.

422. Tree-Planting. — In those portions of the country which are naturally forest-covered it is not usually worth while to start large pieces of woodland by seeding or by transplanting young trees. The cheaper plan is to leave trees enough in the tracts cut over by the lumberman to re-seed the land and so keep up the covering of forest. But in treeless regions, as the prairies and the Great Plains, it is often a matter of much importance to secure belts of trees or considerable wooded areas (Sect. 423). This may be done by planting the seeds of the desired species in the places where the trees are to remain, or by setting out seedling trees procured from nurseries. The latter plan is much the more certain to insure success, as young trees that have been once or twice transplanted have no long roots and are not much checked in their growth by being set out where they are finally to grow. Coniferous and broad-leaved trees are freely planted on a large scale. Among the most desirable species of the former are several spruces, and the white pine, the Scotch pine, and the Austrian pine. Broad-leaved trees which are considerably planted, especially in the Central Plains region (*e.g.*, Nebraska) are cottonwood, silver or white maple, green ash, honey locust, hardy catalpa, black walnut, eucalyptus, and red oak.

423. Influence of Forests on Climate and Water Supply. — The effect which forests have on the temperature of the air and on the amount of rainfall in their neighborhood has not been fully determined. But it is well known that woodlands and even narrow belts of timber are of great service in winter by shutting off cold winds. For thus acting as wind-breaks coniferous evergreen woods are of course more effective than deciduous ones. Tree belts have been largely planted in the more northerly prairie states for the protection which they afford.

PLATE XIV. Oak Saplings springing from a Stump.

Regulation of the water supply is, however, the most important service which forests render, aside from their value as sources of timber. It is a matter of common observation that when a wooded region is stripped of its trees, brooks and rivers are subject to violent floods in the season of heaviest rain or at the melting of the snows, while during the drier months springs fail and streams run low, so that their beds may be only a series of pools. These facts are due to the regulative effect of the forest floor on the distribution of water which falls as rain or snow. On bare ground, not even covered with grass, a large portion of the rainfall is at once carried off to the nearest streams. Even on grasslands the run-off is rapid, as is shown by the quick rise of prairie rivers after a heavy rain. But the leaf-covered forest floor, often carpeted with moss, holds water like a sponge and continues to deliver it for many days after every heavy rain or period of melting snow. This gradual delivery of water, part of it draining off along the surface, part of it soaking into the soil and then slowly finding its way underground into springs and streams, makes the watercourses of a heavily forested region comparatively permanent and constant, delivering considerable water at all seasons of the year and rarely overflowing their banks within a few hours after rains. For this reason it is of the utmost importance that wooded regions like the White Mountains, the Adirondacks, the central and southern portions of the Appalachian system in which many streams have their sources, should be protected by appropriate legislation as soon as they are seriously threatened by the lumberman.

APPENDIX I

[*Additional illustrations, chiefly for use with the Flora in determination of species.*]

I. LEAF FORMS

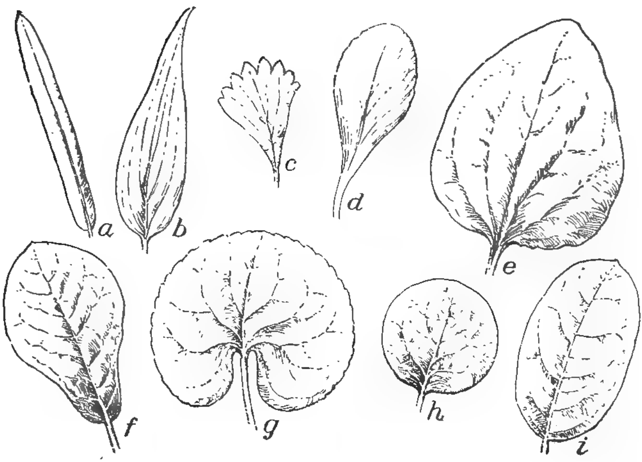


Fig. 1. General Outline of Leaves.

a, linear; *b*, lanceolate; *c*, wedge-shaped; *d*, spatulate; *e*, ovate; *f*, obovate; *g*, kidney-shaped; *h*, orbicular; *i*, elliptical.

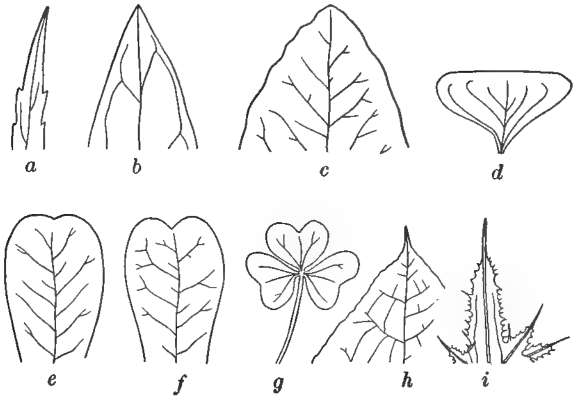


FIG. 2. Tips of Leaves.

a, acuminate or taper-pointed; *b*, acute; *c*, obtuse; *d*, truncate; *e*, retuse; *f*, emarginate or notched; *g* (end leaflet), obcordate; *h*, cuspidate, — the point sharp and rigid; *i*, mucronate, — the point merely a prolongation of the midrib.

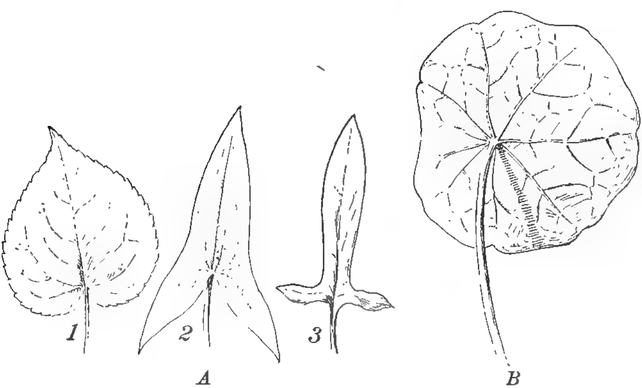


FIG. 3. *A*, Shapes of Bases of Leaves; *B*, Peltate Leaf of Tropæolum.

1, heart-shaped; 2, arrow-shaped; 3, halberd-shaped.

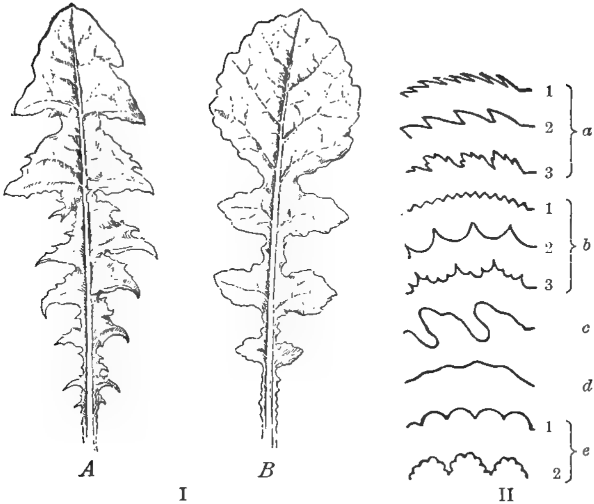
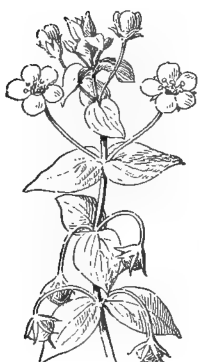


Fig. 4. I. *A*, Runcinate Leaf of Dandelion; *B*, Lyrate Leaf.
II. Shapes of Margins of Leaves.

a (1), finely serrate; (2), coarsely serrate; (3), doubly serrate. *b* (1), finely dentate; (2), sinuate dentate; (3), doubly dentate. *c*, deeply sinuate. *d*, wavy. *e* (1), crenate or scalloped; (2), doubly crenate.

II. FORMS OF FLOWER CLUSTERS



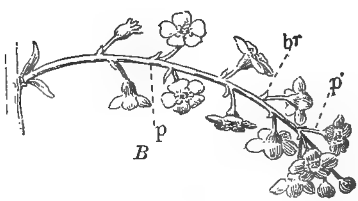


Fig. 5. *A*, Axillary and Solitary Flowers of Pimpernel; *B*, Raceme of Common Red Currant.

p, peduncle; *p'*, pedicel; *br*, bract.

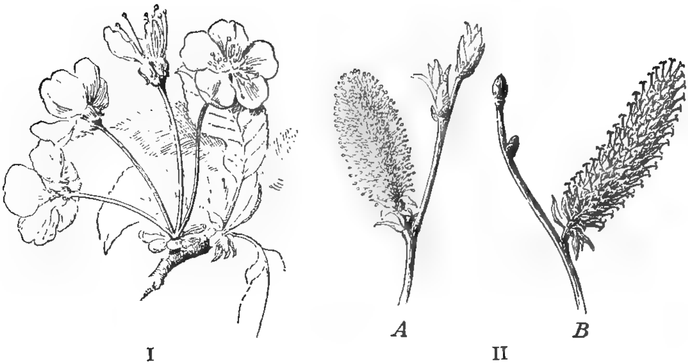


FIG. 6. I, Simple Umbel of Cherry; II, Catkins of Willow.
A, staminate flowers; *B*, pistillate flowers.

FIG. 7. *A*, Spike of Plantain; *B*, Head of Red Clover.

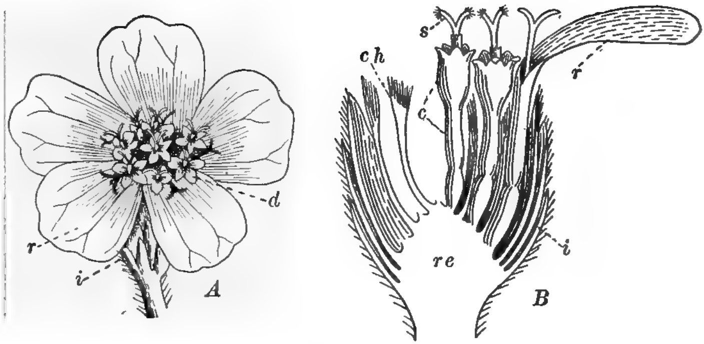


FIG. 8. Head of Yarrow.

A, top view (magnified); *B*, lengthwise section (magnified). *re*, receptacle; *i*, involucre; *r*, ray-flowers; *d*, disk-flowers; *c*, corolla; *s*, stigma; *ch*, chaff, or bracts of receptacle.

FIG. 9. *A*, Panicle of Oat; *B*, Compound Umbel of Carrot.

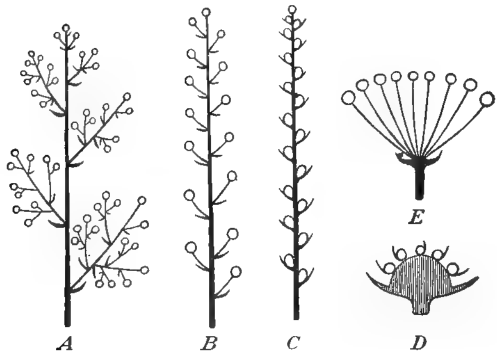


Fig. 10. Diagrams of Inflorescence.

A, panicle; *B*, raceme; *C*, spike; *D*, head; *E*, umbel.

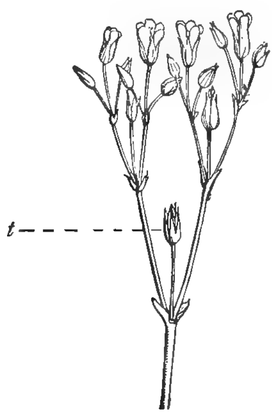


Fig. 11. Compound Cyme of Mouse-Ear Chickweed.

t, the terminal (oldest) flower.

KINDS OF FLOWER CLUSTERS

A. **Indeterminate Inflorescence.**—Order of blossoming from below upward, or from without inward.

1. *Axillary flowers.* Flowers growing in the axils of ordinary leaves.
2. *Raceme.* Flowers with flower-stalks called *pedicels* arranged along the *peduncle* or stem in the axils of special (usually pretty small) leaves called *bracts*.
3. *Corymb.* Flowers arranged as in the raceme, but with the lower pedicels so lengthened as to make the flower cluster flat or nearly so (as in the hawthorn or the yarrow).
4. *Umbel.* Flowers with pedicels of nearly equal length, all appearing to spring from a common point, like the ribs of an umbrella. An *involucre* of bracts usually surrounds the bases of the pedicels.
5. *Spike.* Flowers as in the raceme, but *sessile*, that is without pedicels.
6. *Head.* Flowers as in the spike, but the cluster nearly globular.
7. *Panicle.* Flowers as in the raceme, but the cluster made compound by the branching of the peduncle.

B. **Determinate Inflorescence.** — Order of blossoming from within outward.

1. *Flower terminal.* One flower borne at the summit of the stem.
2. *Cyme.* Flowers much as in the umbel, but the innermost blossoming first.

APPENDIX II

LABORATORY DIRECTIONS

For much more detailed laboratory work than has been outlined in the present book see Bergen and Davis' *Laboratory and Field Manual of Botany* (Ginn & Company). A series of type studies of spore-plants and of representative species of seven families of seed-plants is there given, and the subject of ecology is treated with some care. The selection, preservation, and preparation of material for histological work is carefully described. A glossary of botanical terms is given in the *Manual*.

APPARATUS

The equipment of apparatus necessary for the laboratory and for the individual student is discussed in the *Manual*. Some special pieces of apparatus may, however, be mentioned in this place. For experiments on the relation of temperature to the germination of seeds, and for determining the highest temperatures which blue-green algæ, bacteria, or other organisms can support, it is convenient to have a small, warm chamber, or incubator (thermostat). Such a chamber of 22 × 30 × 22 cm. inside dimensions may be had of Eimer & Amend, 205–211 Third Ave., New York, for $40, and larger ones at higher prices if desired. For some purposes a differential thermostat, as described by Professor W. F. Ganong,[1] is still better.

The apparatus to measure sap pressure (p. 47) may, as suggested by Professor Ganong, advantageously be replaced by a pressure-gauge consisting of a column of air contained in a perfectly cylindrical glass tube, closed at the upper end. Before such a gauge is used Boyle's law for pressure and volume of gases should be explained to the class and experimentally illustrated.

[1] *Laboratory Course in Plant Physiology*, Henry Holt & Co., New York.

Tools for the manufacture and repair of apparatus will be found almost indispensable in the laboratory. Among the most useful are round files for cork-boring and triangular ones for cutting glass, a hammer, nails and brads, fine carpenter's saw, hack-saw, pliers and cutting pliers, chisels, brace with bits and twist drills, annealed brass wire, small soldering copper with solder and zinc-chloride soldering solution.

The Compound Microscope. — Compound microscopes and accessories may be bought of most dealers in physical apparatus. Four of the most important manufacturers are the Bausch & Lomb Optical Co., Rochester, N.Y.; E. Leitz, 30 East Eighteenth St., New York City; the Spencer Lens Co., Buffalo, N.Y.; and C. Zeiss, represented by the Bausch & Lomb Co. All send catalogues on application, and all furnish instruments suitable for high-school laboratories at prices ranging from $20 to $35. The microscopes of German manufacture (of Leitz and Zeiss) are imported duty free for schools.

A very brief account of the construction and use of the compound microscope is given in the *Manual*, pp. 10–14. More details can be found in Winslow's *Elements of Applied Microscopy*, John Wiley & Sons, N.Y., or in any of the standard treatises, such as Gage's, or Carpenter and Dallinger's.

School microscopes are very commonly provided with a 2-inch and a 1-inch eyepiece and a $\frac{2}{3}$-inch and $\frac{1}{6}$-inch objective. In this case either eyepiece when used with the lower objective will give a *low power*. The 2-inch eyepiece with the $\frac{1}{6}$-inch objective will give a *medium power*, and the 1-inch eyepiece with the $\frac{1}{6}$-inch objective will give a moderately *high power*.

It will be found desirable to equip many if not all of the stands also with a 2-inch objective, as this gives a far better general view of such objects as sections of roots or stems of seed plants, green algæ, small liverworts, fern prothallia, and so on than can be obtained with a hand lens. If possible, the laboratory should have at least one stage micrometer, several eyepiece micrometers, and a camera lucida. The micrometers should be kept in frequent use to give the students accurate ideas of the dimensions of objects studied, and the camera lucida should be used as a check on the accuracy of drawings made from the microscope without it.

BIBLIOGRAPHY

In this place only a few suggestions will be given to supplement the bibliography of the *Manual*. The books which are there double-starred are among the most important for reference. Some, however, like Pfeffer's *Physiology of Plants*, are very expensive, and such briefer works as Peirce's *Text-Book of Plant Physiology* (Henry Holt & Co., New York), or Green's *Introduction to Vegetable Physiology* (P. Blakiston's Sons & Co., Philadelphia), may be bought as an alternative. It is often found difficult to identify even the genera of algæ and fungi which are encountered in collecting. For fresh-water algæ and some aquatic fungi no book is more useful than Whipple's *Microscopy of Drinking Water* (John Wiley & Sons, New York). Many fungi can be identified by means of Massee's *Text-Book of Fungi* (The Macmillan Company, New York).

SPECIAL TOPICS FOR STUDY

Economic Botany. — Few subjects will be found to interest most classes more than some of the topics of economic botany. These can often be assigned for optional work, for which credit may be given. The topics to be suggested would vary much, according to the environment of the school. In agricultural districts reports on local conditions as regards use of improved seed for farm and garden crops, on trials of new economic plants, on tree-planting and the management of wood lots, would all prove valuable subjects for discussion. City high-school classes can find fewer opportunities for reports and investigations, but some practicable topics are the comparative value of various species of shade trees and the insect enemies of each species, the sources of the winter flower-supply and modes of forcing flowers, the examination of the gross and histological characteristics of woods and the classification of these by families and according to their structural likenesses, the study of commercial fibers, the histological examination of vegetable foods (such as starches) and of powdered drugs. Many interesting and valuable studies of the relation of microscopic organisms to fermentation and decay may be made with simple apparatus, as described in Conn's *Bacteria, Yeasts, and Molds in the Home* (Ginn & Company).

Ecology. — It will not usually be found worth while to undertake ecological studies unless considerable field work (or at any rate, out-of-door work) can be done. It is almost useless to discuss adaptations to environment unless the environment itself is as much under observation as are the plants that live in it. A good deal of ecology can be interwoven during trips undertaken mainly for the purpose of getting acquainted with the local flora and collecting for the school museum and laboratory. The first requisite for teaching the rudiments of ecological botany is to impress upon the student the reality and severity of the struggle for existence among plants, since competition must exist in order to make adaptation necessary. Any such studies as are suggested in Sects. 154–156 of the *Manual* may be undertaken for this purpose. Even boxes of seedlings grown in a Wardian case or on a sunny laboratory window sill will help to show the effects of competition.

Many ecological topics, such as field studies of parasitism, of insect pollination, of ecological classes, or of plant formations may profitably be assigned as voluntary work to single students or small groups observing together.

INTERPRETING RESULTS OF LABORATORY WORK

Most of the results of physiological experiments can be judged by reference to the statements of Pfeffer, Detmer, and other authorities, and morphological and histological work may be reviewed by comparison with the statements and the figures found in such general treatises as the Strasburger text-book, in the Strasburger-Hillhouse *Practical Botany*, and in special works. But the teacher will find it indispensable to keep for reference a full illustrated set of notes of the year's work, and to add to this year by year as additional types are studied or new results are obtained in any of the experiments performed as demonstrations or by the class.

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Starred page numbers indicate where cuts occur. App. refers to the Appendix.

KEY AND FLORA

NORTHERN AND CENTRAL STATES

BY

JOSEPH Y. BERGEN, A.M.

REVISED AND ENLARGED

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PREFACE

This flora is a considerably enlarged revision of the one prepared by the author in 1901. It does not profess to describe all the conspicuous seed plants of any locality, but rather to comprise a large number of the most available spring-blooming species over an extensive region. More than a hundred species have been added to the list included in the older edition, mainly of plants which range westward to the moderately high plains. The little book may therefore afford a good deal of practice in the determination of species to secondary-school pupils in states even as far west as the Dakotas, Nebraska, Kansas, and Oklahoma. It extends south about to the southern boundary, of Kansas on the west and to that of Virginia on the east.

In the matter of nomenclature it seems best for those who do not wish to be hopelessly sectional to follow the rulings of the Vienna Congress. The author deems himself fortunate to have been able in this connection to avail himself of the decisions of the staff of the Gray Herbarium, as embodied in the seventh edition of Gray's *Manual of Botany*, and to get advice from the same source in regard to names of cultivated plants not described in the Manual. His most sincere thanks are hereby tendered for this invaluable assistance.

At the risk of sometimes seeming pedantic the writer has adopted the practice of discarding, for the most part, such unscientific expressions as "stemless plants," "radical leaves," "calyx adnate to the ovary," and several others. It is certain that if the plant descriptions which contain such terms were now being framed for the first time on the basis of present-day morphology, these terms would not be used.

Most of the plants here described bloom before the end of the school year, and it is believed that all of those which occur toward the southern limits of the territory covered will be found to flower there considerably before the end of June. It may be found worth while, in the case of some *Umbelliferæ*, *Boraginaceæ*, and *Compositæ*, to collect fruit during the summer before it is to be used, preserve it either dry or in preservative fluid, as may seem best, and use it with freshly collected flowers in the determination of species.

No systematic work with seed plants can be of much use unless the teacher takes constant pains to bring out the idea of actual relationship by descent among the forms studied, and to show, in the simpler cases available, some of the steps of evolution. The beginner must not be allowed to suppose that the flora which he is using contains more than a small fraction of the total number of plants even in the families treated. He must be made to realize that the *Rubiaceæ*, for instance, of which he has fourteen species described, really number as many as 4500 species, and the *Compositæ*, instead of mustering a few dozen strong, number in all at least 12,000 species. For such comparisons Engler's *Syllabus der Pflanzenfamilien* will be found to contain the most recent and compact summary.

A somewhat complete (phanerogamic) flora of the student's region should be constantly in use. For this purpose the author prefers to all others the seventh edition of Gray's *Manual of Botany*. For the convenience of those who may find it necessary to use Britton's *Manual of the Flora of the Northern States and Canada*, the generic name used by Britton will generally be found in parenthesis after the name sanctioned by the Vienna code. In cases where Britton's genus covers only part of the genus as given in this book, a statement to that effect is made, as on p. 186, — B. Fl. species 4 (*Naumburgia*). For suggestions about literature see Bergen and Davis, *Laboratory and Field Manual of Botany*, p. 230.

The novice should find a good deal of help in understanding the structure of some of the more difficult flowers and fruits in the illustrations which accompany several families. Most of these have been redrawn for the present edition by Mr. E. N. Fischer of Boston.

J. Y. B.

CAMBRIDGE, MASSACHUSETTS

HOW TO USE THE KEY AND FLORA

In order to determine an unknown species, the student is first to make a careful examination of the plant in hand. After noting in a general way the appearance of the root, stem, and leaf, including a cross section of the stem, he should study the number of the parts of the flower, then make and draw a cross section and a lengthwise section of it. The kind of symmetry of the calyx and corolla, peculiarities in the shape, structure, or operation of the essential organs, such, for instance, as anthers discharging through chinks in the end, should be noted.

Next, the inquirer should look carefully through the key to the families. He is first to decide whether the plant in question is a Gymnosperm or an Angiosperm; if not a coniferous tree or shrub, it will of course belong to the latter division. He is then to settle the question whether it is a Monocotyledon or a Dicotyledon; then under what division of the group the plant comes; and, finally, to decide upon its family.

Turning now to the page at which the family is described, a rapid inspection of the characteristics of the genera will make it evident to which one the species under examination belongs. It may not infrequently prove that none of the genera described agree with the plant studied, and in that case the student must either consult a larger flora or rest satisfied with having determined the family to which his specimen belongs. The identification of the species, after the genus has been reached, presents no difficulty in a little flora like the present one.

A single example may suffice to illustrate more in detail the manner of determining species. Suppose the student to have in hand a flowering specimen of lily of the valley. Turning to the key, page 5, it is evident from the statements concerning Gymnosperms that the plant does not belong under that head. Under Angiosperms it is clear, from the numerical plan of the flower (in threes) and the parallel-veined leaves, that the plant is a Monocotyledon. Among Monocotyledons three general groups are designated by as many numbers in parenthesis. The flower in hand belongs under (3) "Flowers not on a spadix." Under this head the choice is first between (*a*) "Carpels numerous and separate" and (*b*) "Carpels united." In the lily of the valley they are united. The next choice is between "* Perianth hypogynous" and "** Perianth not hypogynous." This flower is hypogynous. The families with hypogynous perianth are grouped under three divisions (distinguished by †, ††, ††† respectively), and of these the last, with its "Perianth actinomorphic, its divisions all alike or nearly so, petal-like," corresponds to the flower under examination and refers the student to "10. Lily Family, page 6." Turning to the key to the genera of the Lily family, page 31, two subfamilies are found. Since the plant is not a climber it belongs to "Subfamily I. Liliaceæ Proper."

This subfamily is divided into five groups designated by capital letters. The lily of the valley has an undivided style and springs from a rootstock, therefore it belongs to group B. Reading the descriptions under B, none is found to agree with the plant in hand until the next to the last is reached: "Leaves only 2, directly from the rootstock. Flowers in a raceme, bell-shaped, white, sweet-scented, *Convallaria.*"

Referring now to the genus, it is found that there is only one species and that one agrees with the specimen in hand. It is therefore *Convallaria majalis*, and the name (as indicated by the L. which follows it) was given by the great Swedish naturalist, Linnæus.[1]

The author does not believe in spending much of the school time of a class upon identifying species, but would rather recommend comparative studies of as many plants of a group as are accessible, and making these studies thorough enough to bring out fully the idea of the family, the genus, and the species.[2] The descriptions in this flora may be used as a check on the cruder ones which the pupil is first to frame for himself.

[1] It will greatly simplify matters if the teacher throughout selects for examination only such species as are described in the flora.

[2] The teacher will find abundant suggestions for such a course in Spalding's *Introduction to Botany*, pp. 152–260.

KEY TO THE FAMILIES OF FLOWERING PLANTS DESCRIBED IN THIS FLORA

CLASS I

GYMNOSPERMS. Ovules not inclosed in an ovary.

Trees or shrubs. Leaves usually evergreen and needle-shaped, awl-shaped, or scale-like. Flowers monœcious or diœcious. Fruit a scaly cone, or sometimes appearing berry-like. 1. Pine Family, page 13

CLASS II

ANGIOSPERMS. Ovules inclosed in an ovary.

SUBCLASS I. — MONOCOTYLEDONS. Flowers usually with their parts in threes, never in fives. Leaves usually parallel-veined. Cotyledon 1.

	Family	Page
(1) Flowers inclosed by chaffy bracts.		
Flowers 2-bracted. Leaves 2-ranked. Stem cylindrical	4. Grass . . .	22
Flowers 1-bracted. Leaves 3-ranked. Stem triangular	5. Sedge . . .	23
(2) Flowers on a spadix.		
Spadix slender, hairy, and bristly .	2. Cat-Tail .	20
Spadix fleshy	6. Arum . . .	24
(3) Flowers not on a spadix.		
(*a*) Carpels usually numerous and nearly or entirely separate	3. Water Plantain .	21
(*b*) Carpels united.		
* Perianth hypogynous or nearly so.		
† Perianth actinomorphic, its parts similar, green, or chaffy	9. Rush	30
† † Perianth of 2 sets, one sepal-like, the other petal-like.		
Style and stigma 1. Petals 3 or 2, soon disappearing	7. Spiderwort . .	26

	Family	Page
Styles or stigmas 3, separate. Petals 3, lasting several days. Leaves netted-veined .	10. (*Trillium*) Lily .	30
Style 1, stigma 3-lobed or 6-toothed.		
Corolla not actinomorphic. Aquatic herbs with parallel-veined leaves	8. Pickerel Weed .	28
† † † Perianth actinomorphic, its divisions all alike or nearly so, petal-like . . .	10. Lily .	30
* * Perianth not hypogynous.		
Anthers 6	11. Amaryllis .	43
Anthers 3 . .	12. Iris . . .	45
Anthers 1 or 2 . .	13. Orchis . . .	47

SUBCLASS II. — DICOTYLEDONS. Flowers usually with their parts in fives or fours. Leaves netted-veined. Cotyledons 2.

I. Apetalous Division. Flowers without a corolla or without either calyx or corolla.[1]

A

Flowers monœcious or diœcious, one or both sorts in catkins.		
(1) Staminate flowers in catkins, the pistillate ones solitary or clustered.		
Leaves pinnately compound . .	16. Walnut . .	52
Leaves simple . . .	18. Beech	58
(2) Both kinds of flowers in catkins.		
(*a*) Leaves alternate.		
Ovaries in fruit becoming fleshy and combining into an aggregate fruit .	20. Mulberry . .	64
Fruit 1-seeded, a drupe or minute nut. Aromatic shrubs	15. Bayberry .	51
Fruit a capsule, seeds with silky hairs .	14. Willow .	48
Fruit a minute nut or akene. Mostly large shrubs or trees, not very aromatic .	17. Birch . .	54
(*b*) Leaves opposite, small parasitic shrubs . .	23. Mistletoe . .	68

B

Flowers not in catkins, both calyx and corolla wanting	45. Sycamore .	113

[1] When only one floral envelope is present, this is said to be the calyx and the corolla is considered to be missing.

C

Flowers not in catkins; calyx present, sometimes petal-like.	Family	Page
(1) Trees or shrubs.		
Flowers not hypogynous; plants not climbing .	74. Dogwood .	175
Flowers not hypogynous; climbing plants	24. Dutchman's Pipe	68
Flowers hypogynous.		
Style single, not cleft, fruit a key (*Fraxinus*)	79. Olive . .	189
Style single, not cleft, fruit a drupe .	38. Laurel .	95
Styles 2 or 2-cleft, fruit 1-celled . .	19. Elm . .	62
Styles 2 or 2-cleft, fruit 2-celled .	59. Maple . .	151
Styles 3, each 2-cleft. Ovary 3-celled	54. Spurge . .	145
(2) Herbs.		
Flowers not hypogynous; ovary 6-celled	24. Dutchman's Pipe	68
Flowers not hypogynous; ovary 1-celled; flowers in umbel-like clusters	22. Sandalwood .	67
Flowers hypogynous.		
(*a*) Ovary 1-celled.		
Stamens many	33. Buttercup . .	83
Stamens few.		
Stipules sheathing the joints . . .	25. Buckwheat .	69
Stipules wanting.		
Rather fleshy herbs	26. Goosefoot	72
Not fleshy.		
Ovules on a free central placenta; delicate, soft-leaved herbs. (*Stellaria*) .	31. Pink . .	77
Ovule single, coarse herbs . .	27. Amaranth .	74
(*b*) Ovary several-celled.		
Small prostrate herb; leaves spatulate, whorled	29. Ice Plant	76
Stipules present, not sheathing.		
Style single . . .	21. Nettle . .	66
Styles 2	20. Mulberry . .	64
Flowers hypogynous, ovary 3-celled	54. Spurge . . .	145
Flowers hypogynous, ovary 5–10-celled; fruit a berry	28. Pokeweed . .	75

II. Choripetalous Division. Calyx and corolla both present, the petals not united.

A

Stamens more than 10.	Family	Page
(1) Trees, shrubs, or woody vines.		
(*a*) Leaves alternate.		
* Ovary 1, simple.		
Fruit a drupe	46. Rose	113
** Ovary 1, compound; fruit dry.		
Ovary 5-celled, 1–2-seeded at maturity	64. Linden	157
Ovary 3-celled, many-seeded	69. Begonia	164
*** Ovary 1, compound; fruit fleshy	46. Rose	113
**** Ovaries numerous.		
† Leaves with stipules.		
Stamens inserted on the receptacle	35. Magnolia	92
Stamens many, monadelphous	65. Mallow	158
Stamens inserted on the calyx	46. Rose	113
†† Leaves not with stipules.		
Small trees	37. Papaw	94
(*b*) Leaves opposite; fruit dry.		
Ovary single, 3–5-celled	44. Saxifrage	109
Ovaries several, inclosed by the calyx tube	36. Calycanthus	94
(2) Herbs.		
(*a*) Ovary single, simple; fruit a berry	34. Barberry	91
(*b*) Ovaries several, simple.		
Stamens inserted on the receptacle	33. Buttercup	83
Stamens inserted on the calyx	46. Rose	113
(*c*) Ovary compound.		
Aquatic herbs, leaves flat	32. Water Lily	82
Marsh herbs, leaves tubular	43. Pitcher Plant	108
Terrestrial herbs.		
* Ovary 1-celled.		
Placentæ central, juice watery	30. Purslane	76
Placentæ parietal, juice milky or colored	39. Poppy	96
Placentæ 2, parietal	41. Caper	107
Placentæ 3 or more, parietal.		
Leaves alternate	42. Mignonette	108
Leaves opposite	66. St. John's-wort	160
Leaves apparently wanting; stems fleshy	70. Cactus	166
** Ovary several-celled; stamens monadelphous	65. Mallow	158
*** Ovary 3-celled; stamens not much if at all monadelphous; stems fleshy, juice acid	69. Begonia	164

B

Stamens not more than 10.

	Family	Page
(1) Trees, shrubs, or woody vines.		
(*a*) Fruit a drupe.		
Stamens 2, rarely 3–4	79. Olive	189
Stamens as many as the petals.		
Flowers bisexual.		
Stamens 4, alternate with the petals	74. Dogwood	175
Stamens 5, alternate with the petals	55. Sumac	148
Stamens 4–5, opposite the petals	62. Buckthorn	154
(*b*) Fruit a berry.		
Stamens alternate with the petals.		
Inserted on the calyx, leaves simple	44. Saxifrage	109
Inserted on a disk surrounding the ovary; leaves compound	72. Ginseng	169
Stamens opposite the petals	63. Grape or Vine	155
(*c*) Fruit a 2-seeded capsule or a key.		
Leaves compound	52. Rue	144
(*d*) Fruit a 2-celled, many-seeded capsule; flowers large, yellow	79. Olive	189
(*e*) Fruit a 3–5-celled capsule; flowers small, greenish, or brown-purple; leaves simple	57. Wahoo	150
(*f*) Fruit 5-lobed, the 5 carpels separating when ripe; flowers rather large, white, or of showy colors; leaves simple	48. Geranium	140
(*g*) Fruit a 1–3-celled capsule, leaves compound, flowers zygomorphic	60. Buckeye	152
(*h*) Fruit a 3-celled bladdery capsule, leaves compound, flowers actinomorphic	58. Bladder Nut	151
(*i*) Fruit a legume	47. Pea or Pulse	126
(2) Herbs.		
(*a*) Ovary single, 1-celled, simple or compound.		
* Corolla actinomorphic or nearly so.		
Sepals and petals 4–5; stamens 5, 10, or 12, distinct.		
Leaves alternate.		
Stigma single	47. Pea or Pulse	126
Stigmas 4 or 2	44. Saxifrage	109
Leaves opposite, punctate, flowers yellow	66. St. John's-wort	160
Leaves opposite, flowers white or red	31. Pink	77
Sepals and petals 4–5; stamens 5, united	68. Passion Flower	163
Sepals 2, petals 4–5	30. Purslane	76

	FAMILY	PAGE
Sepals 6, stamens hypogynous, opposite the petals	34. Barberry . .	91
** Corolla zygomorphic.		
Fruit a legume	47. Pea or Pulse . .	126
Fruit a capsule.		
Stamens 5	67. Violet . . .	161
Stamens 6, in 2 sets	39. Poppy . .	96
(*b*) Ovary single, 2-5-celled, fruit usually dry.		
* Ovary 2-celled (or 2 carpels nearly separate).		
Flowers in umbels, stamens 5 . . .	73. Parsley . .	170
Flowers not in umbels, petals 4 or 0, stamens 6	40. Mustard . .	99
Flowers not in umbels, petals 5, stamens 10 .	44. Saxifrage . . .	109
Flowers not in umbels, petals 3, stamens 6 or 8	53. Polygala	145
** Ovary a 4-celled capsule	71. Evening Primrose	168
*** Ovary of 3 nearly distinct lobes, which become thick and fleshy in fruit	50. Indian Cress . .	142
**** Ovary a 5-celled capsule.		
† Leaves simple.		
Parasitic white or yellowish herbs, or evergreen herbs, not parasitic, capsule many-seeded	75. Pyrola . . .	177
Terrestrial, not much if at all fleshy, capsule 5-10-seeded	48. Geranium . . .	140
Terrestrial, stem fleshy and translucent, capsule elastic, several-seeded . . .	61. Balsam	153
†† Leaves of 3 leaflets . .	49. Wood Sorrel .	142
(*c*) Ovary of 5 principal cells, each more or less divided by a partition into 2 cells; seeds flattish, with a mucilaginous coating	51. Flax . . .	143
(*d*) Ovary single, 2-5-celled; fruit a berry	72. Ginseng . .	169
(*e*) Ovaries 2, seeds hairy-tufted . . .	82. Milkweed .	194

III. Sympetalous Division. Calyx and corolla both present, the petals appearing more or less united.

(1) Trees, shrubs, or woody vines.		
(*a*) Leaves alternate.		
* Fruit splitting open.		
Fruit a legume	47. Pea or Pulse .	146
Fruit a 5-celled capsule	76. Heath	179
** Fruit not splitting open, a drupe	56. Holly	149
*** Fruit a berry.		

	Family	Page
Ovary superior; seeds few, large	78. Ebony	188
Ovary superior; seeds many, small	89. Nightshade	214
Ovary inferior	76. Heath	179
(*b*) Leaves opposite.		
* Fruit a 2-celled, 2-seeded capsule	95. Madder	227
** Fruit a 2-celled, many-seeded capsule.		
Seeds large, winged	91. Bignonia	222
Seeds not winged except in *Diervilla;* shrubs	96. Honeysuckle	230
*** Fruit a 5-celled capsule	76. Heath	179
**** Fruit a drupe or berry.		
Fruit 1-2-seeded (in *Forsythia* many-seeded); stamens 2	79. Olive	189
Fruit 1-4-seeded; stamens 4	87. Verbena	207
Fruit 1-5-seeded; stamens 5	96. Honeysuckle	230
(2) Herbs.		
(*a*) Ovary superior, flowers regular.		
* Ovary separating into 2 distinct follicles.		
Style single, stamens distinct	81. Dogbane	192
Styles 2, stamens united.	82. Milkweed	194
** Ovary 1-celled.		
Fruit a legume	47. Pea or Pulse	126
Fruit a capsule.		
Leaves alternate.		
Stamens opposite the lobes of the corolla	77. Primrose	184
Stamens alternate with the lobes of the corolla	85. Waterleaf	201
Leaves opposite	80. Gentian	191
Leaves all reduced to mere scales, plants never green, root parasites	92. Broom Rape	223
**** Ovary 2-several-celled.		
Stamens 2 or 4	94. Plantain	225
Stamens 5, cells of the ovary 1-2-seeded.		
Fruit separating into 4 nutlets	86. Borage	203
Fruit a capsule	83. Morning-Glory	197
Stamens 5, cells of the ovary several-seeded.		
Stigma 1	89. Nightshade	214
Stigmas 3	84. Phlox	199
(*b*) Ovary superior, flowers zygomorphic.		
* Ovary 1-celled.		
Fruit a legume	47. Pea or Pulse	126

	Family	Page
** Ovary 2–4-celled.		
† Cells each 1-seeded.		
Ovary deeply 4-lobed	88. Mint . . .	209
Ovary not deeply lobed.		
Stamens 2 or 4	87. Verbena . . .	207
Stamens 8	53. Polygala . . .	145
†† Cells each 2-several-seeded.		
Corolla lobes imbricate in the bud .	90. Figwort .	217
Corolla lobes convolute in the bud . .	93. Acanthus . .	224
(*c*) Ovary inferior.		
Flowers in an involucrate head	100. Composite .	239
Flowers not in heads.		
Stamens 3.		
Leaves opposite . .	97. Valerian . .	235
Leaves alternate	98. Gourd . .	236
Stamens 4–5.		
Leaves alternate	99. Campanula . .	237
Leaves opposite or whorled	95. Madder . .	227

CLASS I. GYMNOSPERMS

Plants destitute of a closed ovary, style, or stigma. Ovules generally borne naked on a carpellary scale, which forms part of a cone. Cotyledons often several (Fig. 1).

1. PINACEÆ. Pine Family

Trees or shrubs with wood destitute of ducts, with resinous and aromatic juice. Leaves generally evergreen, and needle-shaped or awl-shaped. Flowers destitute of floral envelopes, monœcious or diœcious, the staminate ones consisting of catkin-like spikes of stamens and the pistillate ones consisting of ovule-bearing scales, arranged in spikes, which ripen into cones.

A

Each scale of the cone borne in the axil of a bract. Seeds 2, with wings.

Leaves evergreen, in bundles of 2–5. Pinus, I

Leaves evergreen, solitary, sessile, keeled on both surfaces. Picea, II

Leaves evergreen, solitary, petioled, flat. Tsuga, III

Leaves solitary, evergreen, flat above, keeled below. Abies, IV

Leaves clustered, deciduous, flat. Larix, V

B

Scales of the cone without bracts, cone becoming globular and woody. Leaves linear.

Leaves alternate, deciduous. Taxodium, VI

Scales of the cone few, without bracts. Leaves evergreen, generally scale-like or awl-shaped.

Cones dry and thin-scaled. Thuja, VII

Cones berry-like. Juniperus, VIII

I. PINUS L.

Sterile flowers somewhat resembling inconspicuous catkins, borne at the base of the young shoot of the season, each flower consisting of pollen-scales in spiral groups (Fig. 1, *2*). Fertile flower spikes consisting of spirally arranged carpel scales, each scale springing from the axil of a bract and bearing at its own base two ovules (Fig. 1, *3*). Fruit a cone, formed of the thickened carpellary scales, ripening the second autumn after the flower opens. Primary leaves, thin and chaffy bud scales, from the axils of which spring the bundles of 2–5 nearly persistent, needle-like, evergreen leaves, 1–15 in. long (Fig. 1).

1. P. Strobus L. White Pine. A tall tree, 75–160 ft. high, much branched and spreading when growing in open ground, but often with few or no living branches below the height of 100 ft. when growing in dense forests. Leaves clustered in fives, slender, 3–4 in. long, smooth and pale or with a whitish bloom. Cones 5–6 in. long, not stout. The wood is soft, durable, does not readily warp, and is therefore very valuable for lumber. In light soil, commonest N.

2. P. Tæda L. Loblolly Pine, Oldfield Pine. A large tree; bark very thick and deeply furrowed, becoming flaky with age; twigs scaly. Leaves in threes, 6–10 in. long, slender, very flexible; sheaths $\frac{2}{3}$–1 in. long. Cones solitary, oblong-conical, 3–5 in. long; scales thickened at the apex, the transverse ridge very prominent and armed with a short, stout, straight or recurved spine. Common, and often springing up in old fields; trunk containing a large proportion of sapwood; timber of little value for outside work.*[1]

3. P. rigida Mill. Northern Pitch Pine. A stout tree, 30–80 ft. high, with rough, scaly bark. Leaves in threes, 3–5 in. long, stiff and flattened. Cones ovoid-conical, 2–3 in. long, their scales tipped with a short, abruptly curved spine. Wood hard, coarse, and resinous, mainly used for fuel. Poor, sandy soil, especially eastward.

[1] Descriptions followed by an asterisk are taken (more or less simplified) from Professor Tracy's flora in the *Southern States Edition*.

4. P. virginiana Mill. SCRUB PINE. A small tree, usually 20–30 ft. high, but sometimes much taller; bark of the trunk rough, nearly black; twigs smooth and with a bloom. Leaves in twos, 1–2 in.

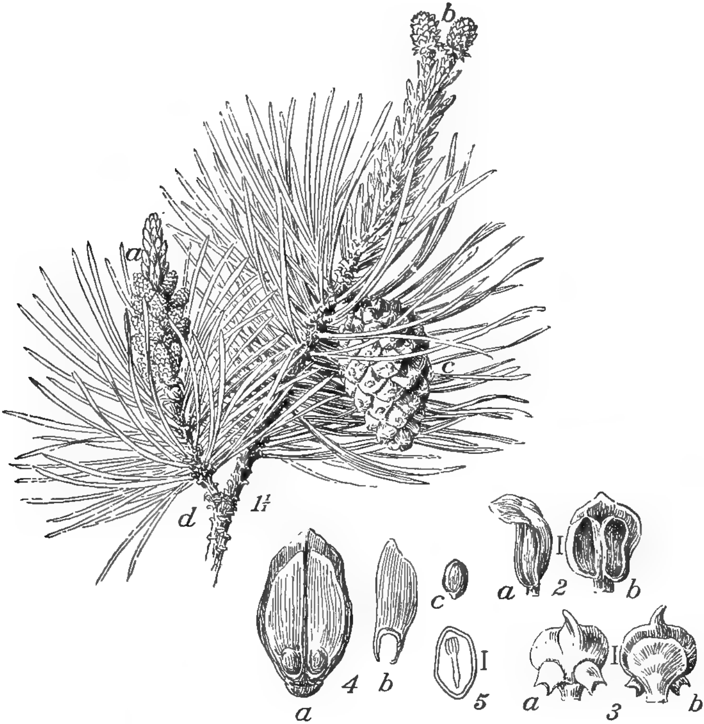


FIG. 1. Scotch pine (*Pinus sylvestris*)

1, a twig showing: *a*, staminate catkins; *b*, pistillate catkins; *c*, a cone; *d*, needles. 2, an anther: *a*, side view; *b*, outer surface. 3, a carpel scale: *a*, inner surface; *b*, outer surface. 4, *a* a cone scale, *b* a seed wing, and *c* a seed. 5, section of a seed, showing the embryo. 1 is natural size; parts 2, 3, and 5 are magnified by the amount indicated by comparison with the vertical line alongside each. (After Wossidlo)

long, rigid, sheaths very short. Staminate catkins dull, yellowish-purple, 1 in. long. Cones solitary, short-peduncled, often reflexed, ellipsoid-conic, about 2 in. long; scales thickened at the apex and armed with a slender, straight or recurved prickle. On dry, sandy soil; wood light, soft, weak, and of little value.*

5. P. sylvestris L. SCOTCH PINE (wrongly called Scotch Fir). A medium-sized tree, with the older bark reddish and scaly. Leaves in twos, 1½–2½ in. long. Cones rather small and tapering (Fig 1, *1*, *c*). Cultivated from Europe.

6. P. resinosa Ait. RED PINE, NORWAY PINE. A tall, rather slender tree, with bark reddish-brown and moderately smooth. Leaves in twos, slender, and 5–6 in. long. Cones borne at the ends of the branches, smooth, about 2 in. long. A valuable timber tree, which often grows in small, scattered clumps; wood firm, pale red, and not very resinous; used in house and bridge building, and for masts and spars.

7. P. palustris Mill. LONG-LEAVED PINE. A large tree; bark thin-scaled, wood very resinous, old trees with only a few spreading branches near the top. Leaves in threes, 10–15 in. long. Sheaths 1–1¼ in. long, crowded near the ends of very scaly twigs. Staminate catkins 2–3 in. long, bright purple, conspicuous. Cones terminal, ellipsoid-conical, 6–10 in. long, diameter 2–3 in. before opening, 4–6 in. when fully opened; scales much thickened at the apex and armed with a short recurved spine at the end. The most common tree in the pine barrens; wood hard, strong, and durable, especially valuable for floors and inside work.*

II. PICEA Link

Sterile flowers generally axillary (sometimes terminal), borne on the twigs of the preceding year. Fertile flowers terminal. Fruit a nodding, thin-scaled cone, ripening in the first autumn. Leaves evergreen, needle-shaped, four-angled, scattered or spirally arranged.

1. P. mariana BSP. BLACK SPRUCE. A small tree, usually only 20 or 30 ft. high, often less. Leaves strongly 4-angled, bluish-green, and glaucous, ¼–¾ in. long. Cones ovoid, pointed, ½–1½ in., usually about 1 in. long, persisting sometimes for 20–30 years. Wood of little value except for paper pulp. The tree is especially abundant northward and is of common occurrence in peat bogs.

2. P. rubra Dietrich. RED SPRUCE. A large tree, 70–80 or even 100 or more feet high, of strict conical habit. Leaves dark green or yellowish and glossy, ½–⅝ in. long. Cones ovoid-oblong, acute, usually 1½–2 in. long, mostly falling the first year. This is the principal timber spruce of the northeastern United States, and furnishes much rather tough lumber for use in floor joists, scantling, and similar purposes.

3. P. canadensis BSP. White Spruce, Skunk Spruce, Cat Spruce. A tall, rather conical tree, 60–70 ft. high. Leaves pale and with a bloom sometimes ¾ in. long. Cones cylindrical, with rounded ends, about 2 in. long, falling inside of one year. A handsome tree, valuable for timber, ranging far northward.

4. P. Abies Karst. Norway Spruce. A large tree. Leaves dark green, ¾–1 in. long. Cones 5–7 in. long. Cultivated from Europe.

III. TSUGA Carrière

Sterile flowers, clusters of stamens springing from the axils of leaves of the preceding year. Cones terminal, on twigs of the preceding year, drooping, thin-scaled, ripening the first year. Leaves minutely petioled, short, flat, white beneath, 2-ranked.

1. T. canadensis Carrière. Hemlock. A large tree, in age branchless below when growing in dense woods. When young the spray is very graceful and abundant. Leaves short-linear. Cones ¾ in. or less in length. The wood is coarse and splintery, but useful for fences and other rough work. The thick reddish bark is of great value for tanning.

IV. ABIES Hill

Sterile flowers from axils of leaves of the preceding year. Cones erect, on the sides of the branches, with deciduous scales, ripening the first year. Leaves scattered, but on horizontal branches appearing 2-ranked, flat above, silvery, and with a prominent midrib below.

1. A. balsamea Mill. Balsam Fir. A slender tree, 50–60 ft., occasionally 80 ft., high, with dense foliage. Leaves narrowly linear, less than 1 in. long. Cones violet-colored until old, cylindrical, 2–4 in. long. The bark contains many large blisters, filled with the well-know Canada balsam. The wood is brittle and of little value.

V. LARIX Mill.

Flower spikes short, opening in early spring, before the leaves; the fertile ones, while still young, of a beautiful crimson color. Fruit a small cone, with thin scales. Leaves none of them scaly, but all needle-shaped, soft, deciduous, very numerous, in little brush-like bundles.

1. **L. laricina** Koch. AMERICAN LARCH, TAMARACK, HACKMATACK (wrongly, but quite generally, called Cypress and Juniper). A tall, slender tree, 30–100 ft. high. Leaves slender and less than 1 in. long, very pale bluish-green. Cones $\frac{1}{2}$–$\frac{3}{4}$ in. long, few-scaled. Wood hard, tough, and heavy, of considerable use for shipbuilding.

2. **L. decidua** Mill. EUROPEAN LARCH. Leaves bright green and longer. Cones longer than in the preceding species and many-scaled. Cultivated from Europe.

VI. TAXODIUM Richard

Trees. Leaves spreading so as to appear 2-ranked, deciduous. Flowers monœcious, appearing before the leaves; staminate ones numerous, globose, forming long, terminal, drooping, panicled spikes; anthers 2–5-celled. Pistillate flowers single or in pairs, bractless, the peltate scales 2-ovuled. Cone globose; the very thick woody scales angular, separating at maturity. Seeds 3-angled, pyramidal.*

1. **T. distichum** Richard. BALD CYPRESS. A very large tree; bark dark brown, rough, fibrous; many of the twigs deciduous with the leaves. Leaves alternate, opposite, or whorled, 2-ranked, flat, linear, $\frac{1}{2}$–$\frac{3}{4}$ in. long. Cones terminal, globose, about 1 in. in diameter; ends of the scales much thickened, wrinkled, and with a distinct triangular marking. Common in swamps and on the borders of streams; wood reddish, soft, light; specially valued for shingles and fence posts, and for boat building.*

VII. THUJA L.

Flowers small, terminal, monœcious, on different branches. Stamens each consisting of a scale-like portion bearing 4 anther-like cells. Pistillate flowers consisting of a few overlapping scales which ripen into a small, loose cone. Leaves evergreen, opposite, and closely overlapping on the stem, of two kinds, those on the more rapidly growing twigs awl-shaped, the others mere scales.

1. **T. occidentalis** L. ARBOR VITÆ, CEDAR. A small tree, 20–50 ft. high, with soft, fibrous bark. Leaves mostly awl-shaped and blunt. Cones ellipsoidal, their scales 2-seeded. Grows on rocky ledges, but reaches its greatest size in cool cedar swamps. Wood soft, yellowish, fragrant, durable, prized for shingles and fence posts.

VIII. JUNIPERUS L.

Flowers very small, lateral, diœcious, or sometimes monœcious. Scales of the staminate flower shield-shaped, with 3–6 anther cells. Fertile flowers with 3–6 fleshy scales which unite into a berry-like, 1–3-seeded fruit. Leaves awl-shaped or scale-shaped.

1. **J. communis** L. JUNIPER. A low, spreading shrub (one variety prostrate in circular masses). Leaves linear-awl-shaped, with needle-like points, each marked with a distinct stripe of bloom along the center of the upper surface, borne in whorls of three. Fruit a dark blue aromatic berry, $\frac{1}{4}$ in. or more in diameter. Grows in dry pastures and on sterile hillsides N.

2. **J. virginiana** L. RED CEDAR, SAVIN. Ranges in size and shape from a low, rather erect shrub, to a conical tree 90 ft. high. Leaves of two kinds, those on the rapidly growing shoots awl-shaped and pointed, those on the shortest twigs scale-shaped, obtuse, or nearly so, and closely appressed to the stem. Fruit small, bluish, with a white bloom. Found all the way from British America to Florida. Wood soft, fragrant, reddish, exceedingly durable in the ground, valued for the manufacture of moth-proof chests and especially for lead pencils.

CLASS II. ANGIOSPERMS

Plants with a closed ovary, in which the seeds are matured. Cotyledons 1 or 2.

SUBCLASS I. MONOCOTYLEDONOUS PLANTS

Stems with the fibrovascular bundles scattered among the parenchyma cells; in perennial plants no annual rings of wood. Leaves usually parallel-veined, alternate, nearly always entire. Parts of the flower generally in threes (never in fives). Cotyledon 1.

2. TYPHACEÆ. Cat-Tail Family

Perennial marsh or aquatic plants. Rootstock stout, creeping; stem simple, cylindrical, erect. Leaves simple, strap-shaped, sheathing at the base, nerved and striate. Flowers monœcious, in a single terminal spike, staminate part of the spike uppermost, each part subtended by spathe-like deciduous bracts. Perianth of fine bristles. Staminate flowers sessile, stamens 2–7; filaments connate, subtended by minute bracts. Pistillate flowers short-pediceled. Ovary 1–2-celled; styles 1–2. Fruit small, nut-like.*

TYPHA L.

Characters of the family.

1. **T. latifolia** L. Cat-Tail. Stem erect, jointed below, 5–8 ft. high. Leaves nearly as long as the stem, about 1 in. wide, netted and with a bloom. Spike cylindrical, dark brown or black; staminate portion above the pistillate, usually without any interval between them, each 4–8 in. long and about 1 in. in diameter. Fruit furrowed. Common in marshes and shallow ponds.*

3. ALISMACEÆ. Water Plantain Family

Annual or perennial marsh herbs, usually with creeping runners or rootstocks. Stems scape-like. Leaves long-petioled, sheathing at the base; petiole rounded; blade nerved, netted, or sometimes wanting. Flowers in racemes or panicles, bisexual, monœcious or diœcious; pedicels in bracted whorls. Sepals 3, persistent; petals 3 or wanting. Stamens 6 or more. Ovaries few or many, 1-celled, 1-seeded; style short or none. Fruit a 1-seeded akene.*

I. SAGITTARIA L

Perennial; rootstocks mostly knobby or tuber-bearing. Scapes erect or decumbent. Leaves long-petioled, sheathing at the base, the blade round and netted, or wanting. Flowers monœcious or diœcious, racemed in 3-bracted whorls of threes, the upper flowers usually staminate. Sepals 3, persistent; petals 3, withering-persistent or deciduous. Stamens few or many. Ovaries in globose heads, 1-ovuled; style short, persistent. Fruit a subglobose head of flattened akenes.*

1. S. latifolia Willd. Broad-leaved Arrowhead. Leaves very variable in size and shape, from broadly sagittate to linear, those growing on the drier soil being usually the broader; petioles 6–30 in. long. Scape smooth or slightly downy, 6–36 in. high; bracts acute. Flowers monœcious or sometimes diœcious, white, 1 in. or more in width; pedicels of the staminate flowers twice the length of those of the fertile flowers. Filaments long, smooth, and slender. Akenes with beak nearly horizontal. Ditches and muddy places.*

2. S. graminea Michx. Grass-leaved Sagittaria. Leaves long-petioled, lanceolate, or elliptical, and acute at each end, 3–5-nerved, or often linear, the earlier often reduced to flattened petioles. Scape slender, usually longer than the leaves, simple, weak, often prostrate in fruit; bracts small, ovate, connate at the base. Flowers monœcious or diœcious, on long, thread-like pedicels, about ½ in. wide. Stamens 10–20, filaments downy. Akenes nearly beakless. In ditches and shallow pools.*

II. ALISMA L.

Annual or perennial herbs. Leaves erect or floating, blades prominently ribbed and netted, or even pinnately veined.

Scapes erect, becoming longer than the leaves, cylindrical, spongy. Flowers bisexual, in paniculate, 3-bracted umbels, small, white or pink. Stamens 6–9. Ovaries numerous in one or more whorls on a flat receptacle. Fruit 1-seeded akenes which are ribbed on the back and sides.*

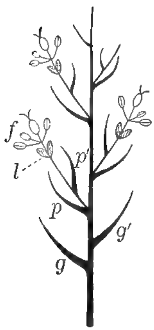


FIG. 2. Diagrammatic representation of a several-flowered grass spikelet

g, *g'*, the glumes; *p*, *p'*, the palets; *l*, lodicules; *f*, a flower. The axis is much lengthened, to separate the flowers. (After Schimper)

FIG. 3. Spike-like panicle of vernal grass (*Anthoxanthum*)

a, mature anthers. (Slightly enlarged)

1. A. Plantago-aquatica L. WATER PLANTAIN. Perennial; root fibrous. Leaves ovate or somewhat cordate, 5–7-nerved when erect, floating leaves narrower and sometimes linear. Scapes usually single; panicle 1–2 ft. long; flowering branches whorled, subtended by three narrow, striate bracts; pedicels slender, elongated. Ovaries 15–20 in a single whorl; base of the short style persistent, forming a beak at the inner angle of the akene. Akenes obliquely obovate, 2–3-keeled on the back. Common in ponds and muddy places.*

4. GRAMINEÆ. GRASS FAMILY

Mostly herbs, with usually hollow stems, closed and enlarged at the nodes. Leaves alternate, in two ranks, with sheathing bases, which are split open on the side opposite the blade. Flowers nearly or quite destitute of floral envelopes, solitary, and borne in the axils of scaly bracts, which are arranged in two ranks overlapping each other on 1–many-flowered *spikelets;* these are variously grouped in spikes, panicles, and so on. Fruit

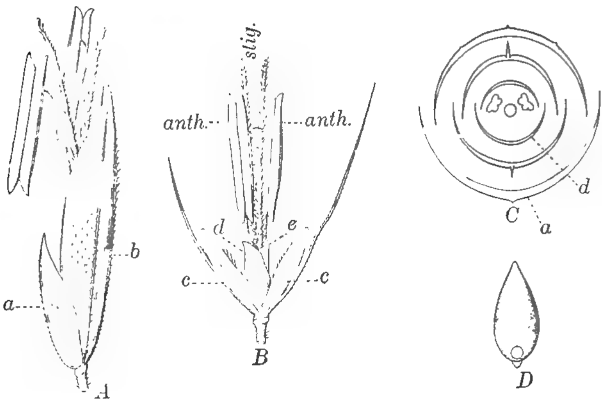


FIG. 4. Vernal grass (*Anthoxanthum*)

A, a one-flowered spikelet: *a*, *b*, the outer empty glumes. *B*, a spikelet with the outer glumes removed: *c*, *c*, the inner empty glumes (neuter flowers) with long, bristle-shaped appendages; *d*, *e*, palets; *anth.*, anthers; *stig.*, stigmas. *C*, diagram of cross section of a spikelet: *a*, glume; *d*, palet. *D*, a fruit. (All magnified.) (After Cosson and De Saint-Pierre)

a grain. (The family is too difficult for the beginner, but the structure and grouping of the flowers may be gathered from a careful study of Figs. 2, 3, 4.)

5. CYPERACEÆ. SEDGE FAMILY

Grass-like or rush-like herbs, with solid, usually triangular, stems, growing in tufts. The sheathing base of the generally 3-ranked leaves, when present, is not slit as in grasses. The flowers are usually somewhat less inclosed by bracts than those of grasses; the perianth is absent or rudimentary; stamens generally 3; style 2-cleft or 3-cleft.

The flower cluster and the flower of a sedge may be understood from an inspection of Fig. 5.

The species are even more difficult to determine than those of grasses.

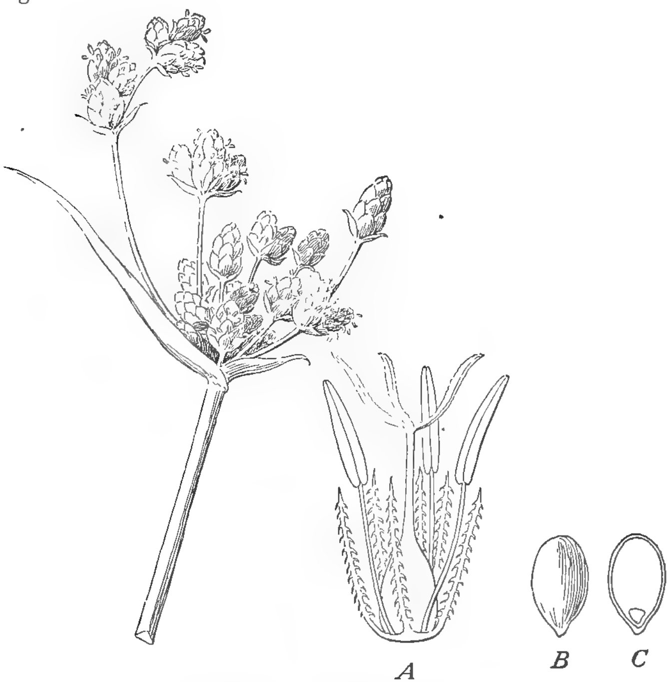


Fig. 5. Inflorescence, flower, and seed, of a sedge (Great Bulrush, *Scirpus lacustris*)

A, magnified flower, surrounded by a perianth of hypogynous bristles; *B*, the seed; *C*, section of the seed, showing the small embryo inclosed in the base of the endosperm. (After Lindley)

6. ARACEÆ. Arum Family

Perennial herbs, with pungent or acrid juice. Leaves often netted-veined. Small, unisexual or bisexual flowers, clustered along a peculiar fleshy spike called a *spadix*, and frequently more or less covered by a large, hood-like bract called a *spathe.* Perianth, when present, of 4–6 parts; often wanting. Fruit usually a berry.

I. ARISÆMA Martius

Perennial herbs, springing from a corm or a tuberous rootstock. Spathe rolled up at base. Summit of spadix naked, the lower part flower-bearing; staminate flowers above, pistillate ones below. Stigma flat. Ovary 1-celled. Berry 1–few-seeded.

1. **A. triphyllum** Schott. INDIAN TURNIP, JACK-IN-THE-PULPIT. Leaves generally 2, each of 3 elliptical-ovate, pointed leaflets. Spadix club-shaped, bearing usually only one kind of fully developed flowers; that is, full-sized pistillate and rudimentary staminate ones, or the reverse. Spathe much longer than the spadix, and covering it like a hood. Corm turnip-like, but much wrinkled, very starchy, and filled with intensely burning juice.

2. **A. Dracontium** Schott. GREEN DRAGON, DRAGON ROOT. Leaf usually single, divided into 7–11 rather narrow, pointed leaflets; spadix tapering to a long, slender point, often bearing fully developed staminate and pistillate flowers.

II. SYMPLOCARPUS Salisb. (SPATHYEMA)

Rootstock very stout, with many long, cylindrical roots. Leaves clustered, very large, and entire. Spathe shell-shaped, very thick. Spadix globular, thickly covered with bisexual flowers. Sepals 4. Stamens 4. Style 4-angled. Fruit globular or ellipsoidal, with the seeds slightly buried in the enlarged spadix.

Coarse, stemless herbs, with a powerful scent like that of the skunk and of onions.

1. **S. fœtidus** Nutt. SKUNK CABBAGE. Leaves many, slightly petioled, 1–2 ft. long, appearing after the flowers. The latter are usually seen before the ground is wholly free from frost, often earlier than any other flower. Bogs and wet meadows, very common N.

III. ACORUS L.

Rootstocks horizontal, long, and moderately stout, aromatic. Leaves long, upright, sword-shaped. Spathe much like the leaves. Spadix projecting from the edge of the spathe, consisting of numerous bisexual flowers. Sepals 6. Stamens 6. Ovary 2–3-celled, with numerous ovules. Fruit 1–few-seeded.

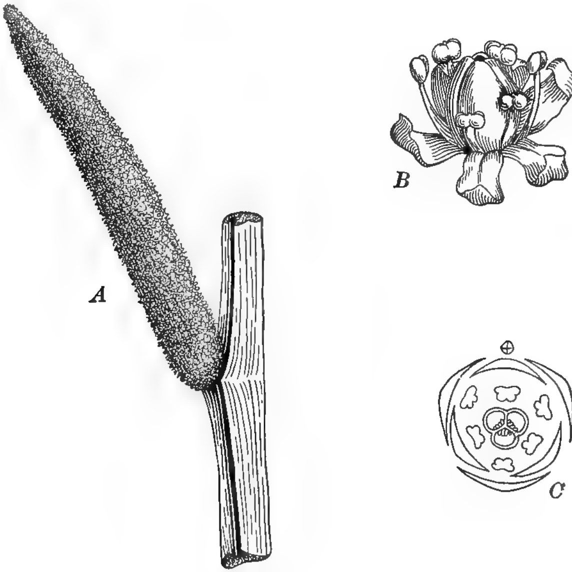


Fig. 6. *Acorus Calamus*

A, spadix; *B*, a single flower, enlarged; *C*, diagram of flower, enlarged. (After Schimper)

1. A. Calamus L. Sweet Flag. Scape with a long, leaf-like prolongation (spathe) beyond the green, very closely flowered spadix. Along borders of brooks and swamps.

The rootstocks furnish the well-known calamus or "sweet flag root" sold everywhere by druggists.

7. COMMELINACEÆ. Spiderwort Family

Herbs, with slimy or mucilaginous juice; stems somewhat succulent, jointed, leafy, simple or branched. Leaves simple, succulent, narrow, entire, sheathing at the base, sheaths entire or split. Flowers in terminal cymes or umbels, bisexual, often zygomorphic. Sepals 3, persistent, foliaceous or colored. Petals 3, soon falling or liquefying. Stamens 6 or fewer, often some of them abortive. Ovary 2–3-celled; style single; stigma entire or 3-lobed. Fruit a 2–3-celled, 2–3-valved capsule; seeds solitary or several in each cell.*

I. TRADESCANTIA L.

Perennial, stem simple or branched. Leaves very narrow. Flowers in terminal and axillary bracted umbels, actinomorphic, 1 in. broad. Sepals 3, herbaceous. Petals 3, soon falling, or liquefying to jelly. Stamens 6, sometimes 3 shorter than the others; filaments bearded or smooth. Ovary 3-celled, with 2 ovules in each cell; pedicels recurved in fruit. Capsule 3-celled, 3-valved, 3–6-seeded.*

1. **T. virginiana** L. Spiderwort. Stem erect, stout, smooth, or with long, soft hairs, 1–2 ft. high. Leaves linear, keeled, often purple-veined, long, taper-pointed, 1 ft. or more in length. Bracts similar to the leaves. Umbels sessile, 2–many-flowered, flowers in 2 rows in the bud. Petals blue or purple, twice as long as the sepals. Stamens blue, filaments densely bearded. Capsule ovoid or oblong. On dry, sandy soil.*

2. **T. pilosa** Lehm. Hairy Spiderwort. Stem stout, erect or zigzag, branched, with long, soft hairs, or nearly smooth, 1–2 ft. high. Leaves linear-oblong, taper-pointed at the apex, narrowed at the base, hairy on both sides. Umbels axillary and terminal, many-flowered. Pedicels and sepals with soft, glandular hairs. Flowers blue or purple, $\frac{3}{4}$–1 in. wide. Seeds pitted. In rich soil.*

II. COMMELINA L.

Annual or perennial, stem branching, erect or procumbent, smooth or downy. Leaves petioled or sessile, entire, the floral ones heart-shaped, folded, and forming a spathe inclosing the base of the cymes. Flowers not actinomorphic. Sepals mostly colored, 1 of them smaller. Petals blue, unequal, 2 of them kidney-shaped and long-clawed, the third one smaller. Stamens 6, only 3 of them fertile; filaments smooth. Capsule 1–3-celled; seeds 1–2 in each cell.*

1. **C. virginica** L. VIRGINIA DAYFLOWER. Stem erect, downy, 1–2 ft. high. Leaves lanceolate to oblong-lanceolate, taper-pointed, 3–5 in. long, somewhat rough above; sheaths inflated, hairy, the opening often fringed. Spathes containing a slimy secretion. Flowers 1 in. wide, the odd petal lanceolate. Capsule 3-seeded, the dorsal cell not splitting open. On moist, sandy soil.*

III. ZEBRINA Schnizl.

Trailing or slightly climbing herbs. Leaves often striped. Flowers usually in pairs. Calyx with a short tube, regularly or irregularly 3-parted. Corolla nearly actinomorphic, with tube longer than the calyx. Filaments naked or bearded. Ovary 3-celled, 3–6-ovuled.

1. **Z. pendula** Schnizl. WANDERING JEW. Stems perennial, prostrate or nearly so, branching freely, rooting easily at the nodes. Leaves somewhat succulent, lance-ovate or oblong, crimson beneath, green or dark purplish above, often with two wide silvery stripes. Cultivated from Mexico.

8. PONTEDERIACEÆ. PICKEREL-WEED FAMILY

Perennial marsh or aquatic herbs, stems simple or branched, succulent. Leaves simple, alternate. Flowers solitary or spiked, each subtended by a leaf-like spathe, perfect, mostly not actinomorphic. Perianth corolla-like, 6-parted. Stamens 3 or 6, unequal, inserted irregularly in the tube or throat of the perianth. Ovary superior, 1- or 3-celled; style single; stigma entire or toothed. Fruit a 1-seeded utricle.*

PONTEDERIA L.

Stem erect, from a thick, creeping rootstock, bearing a single leaf above the middle and several sheathing, bract-like leaves at its base. Radical leaves numerous, thick, parallel-veined. Petiole long, from a sheathing-base. Flowers in terminal spikes. Perianth 2-lipped, lobes of the upper lip ovate, of the lower oblong, spreading. Stamens 6, the 3 upper short and often imperfect, the 3 lower protruding. Ovary 3-celled,

A Fig. 7. Rushes

A, plant of *Juncus tenuis*, one half natural size; B, flower of same, magnified; C, fruit magnified; D, flower of wood rush (*Luzula*), magnified. (D, after Warming) but only 1 cell ovule-bearing; the 1-seeded utricle inclosed by the base of the perianth.*

1. **P. cordata** L. PICKEREL WEED. Stem stout, erect, 2–4 ft. high. Leaves long, from heart-shaped to lanceolate and often halberd-shaped; apex and basal lobes obtuse, finely nerved. Spike dense, 2–4 in. long; peduncles inclosed by the spathe. Perianth hairy, blue, the upper lip with 2 yellow spots; tube 6-ribbed, curved, rather longer than the lobes. Ovary oblong. In ponds and slow streams.*

9. JUNCACEÆ. Rush Family

Grass-like perennial or annual herbs, mostly growing on wet soil. Stems mostly erect but sometimes creeping, simple or branched, naked or leafy and jointed. Leaves cylindrical, sheathing at the base, very slender and pointed or flattened and grass-like. Flowers in cymes or panicles, which may be very loose and spreading, or so compact as to form a head, sometimes with a rigid scape prolonged beyond the flower cluster. Flowers usually bracted. Perianth of 6 nearly equal, scale-like, persistent divisions. Stamens 3 or 6, inserted on the base of the perianth. Ovary free, 1- or 3-celled, many-ovuled; style single; stigmas 3, usually hairy. Fruit a 1- or 3-celled, 3–many-seeded capsule. [Most species flower late in the season, and their identification is too difficult for one without considerable experience.]*

10. LILIACEÆ. Lily Family

Mostly herbs. Flowers actinomorphic. Perianth free from the ovary. Stamens nearly always 6, one before each division of the perianth. Ovary usually 3-celled; fruit a pod or berry, few–many-seeded.

Except in the genus Trillium the divisions of the perianth are colored nearly alike.

SUBFAMILY I. LILIACEÆ PROPER

Not tendril climbers, rarely diœcious.

A

Styles or sessile stigmas 3, more or less separate.

Leaves flat, lanceolate, or spatulate. Flowers diœcious, showy. Chamælirium, I

Leaves grass-like. Flowers bisexual, showy. Amianthium, II

Leaves 3-ranked, strongly nerved and plaited. Flowers somewhat monœcious, small. Veratrum, III

B

Style undivided (in No. XXIII, 3 sessile stigmas). Plants from rootstocks.

Leaves perfoliate. Flowers solitary, drooping, yellow. Uvularia, IV

Leaves broad, clasping. Flowers solitary or nearly so, drooping, yellow. Oakesia, V

Leaves scale-like. Thread-like branches borne in their axils. Flowers small, bell-shaped. Asparagus, XVIII

Leaves several–many, sessile or clasping, alternate. Flowers small, 6-parted, white, in a terminal simple or compound raceme. Smilacina, XIX

Leaves only 2–3, sessile or slightly petioled. Flowers very small, 4-parted, solitary or in a small terminal cluster. Maianthemum, XX

Leaves clasping. Flowers solitary or in pairs, greenish-white or rose-purple, borne on pedicels abruptly bent near the middle. Streptopus, XXI

Leaves nearly sessile or partly clasping. Flowers axillary, greenish, on pedicels jointed near the flower. Polygonatum, XXII

Leaves only 2, directly from the rootstock. Flowers in a raceme, bell-shaped, white, sweet-scented. Convallaria, XXIII

Leaves 3, netted-veined. Flower single, large, terminal. Trillium, XXIV

C

Style undivided. Plants from fibrous roots.

Flowers yellow or orange. Hemerocallis, VIII
Flowers white. Yucca, XVII

D

Style usually undivided. Plants from coated or solid-looking bulbs.

Leafy-stemmed plants. Flowers large, solitary, or apparently umbeled. Fritillaria, X

Apparently stemless plants.

(*a*) Plants with the smell of onions or garlic. Flowers umbeled. Allium, VI
(*b*) Plants scentless. Flowers umbeled. Nothoscordum, VII
(*c*) Flower solitary, erect, large. Tulipa, XII
(*d*) Flower solitary, nodding. Erythronium, XI
(*e*) Flowers racemed. Perianth with hardly any tube. Stigma a single knob. Scilla, XIII
(*f*) Flowers racemed. Perianth with hardly any tube. Stigma 3-cleft. Camassia, XIV
(*g*) Flowers corymbed. Perianth with hardly any tube. Leaves linear. Ornithogalum, XV
(*h*) Flowers racemed. Perianth with a tube. Leaves lance-linear. Hyacinthus, XVI

E

Style undivided. Plants from scaly bulbs. Lilium, IX

SUBFAMILY II. SMILACEÆ

Climbers, often tendril-bearing. Flowers diœcious. Smilax, XXV

I. CHAMÆLIRIUM Willd.

Rootstock short and thick, bitter. Stem simple, erect, leafy, smooth. Lower leaves spatulate to obovate, the stem leaves narrower. Flowers small, white, in a spike-like raceme, diœcious. Perianth of 6 linear-spatulate segments. Stamens 6, filaments longer than the perianth. Ovary 3-celled; styles 3. Fruit an ovoid, 3-angled, many-seeded capsule.*

1. C. luteum Gray. UNICORN ROOT, DEVIL'S BIT. Stem furrowed, staminate plants 1–2 ft. high, pistillate taller, often 3 ft. or more. Lower leaves obovate, clustered, the upper small and bract-like. Staminate racemes slender and drooping, the pistillate erect. Flowers short-pediceled. Capsule 3-valved, seeds linear-oblong, winged at the ends. On low ground.*

II. AMIANTHIUM Gray. (CHROSPERMA)

Stem simple, glabrous, erect from a bulbous base. Leaves long and slender. Flowers white, in a simple terminal raceme, bisexual. Perianth of 6 segments which are sessile and glandless. Stamens 6, somewhat perigynous. Ovary 3-lobed, 3-celled; fruit a dehiscent, 3-lobed capsule, the lobes becoming awl-shaped by the persistent style bases; cells few-seeded.*

1. A. muscætoxicum Gray. FLY POISON. Bulb ovoid or oblong. Stem somewhat angled below, 1–3 ft. high. Lower leaves strap-shaped, channeled, the upper small and bract-like. Raceme dense, cylindrical, pedicels from the axils of minute ovate bracts. Perianth segments ovate, white, becoming greenish, nearly as long as the slender stamens. Styles spreading. Capsule with divergent lobes; seeds ovoid, red. In rich woods.*

III. VERATRUM L.

Simple-stemmed perennials. Roots fibrous, from the thickened base of the stem, poisonous, emetic. Leaves 3-ranked, plaited, and veiny. Flowers panicled, greenish or brownish. Sepals 6, spreading, nearly hypogynous. Stamens shorter than the perianth, and somewhat perigynous. Ovary of 3 carpels united at base. Fruit a few-seeded capsule, splitting into 3 parts.

1. V. viride Ait. WHITE HELLEBORE, INDIAN POKE. Stem stout, 2–7 ft. high, very leafy. Flowers very numerous, in a panicle, composed of spike-like racemes. Sepals yellowish-green. Wet meadows and brooksides.

2. V. Woodii Robbins. Stem slender, 2–5 ft. high, not very leafy. Flowers in a long, narrow panicle. Sepals greenish-purple or almost black. Woods and dry hillsides.

IV. UVULARIA L.

Rather low plants with short rootstocks. Leaves alternate, broad, and parallel-veined. Flowers yellow or yellowish, drooping, borne singly at the end of the forking stem. Perianth of 6 similar and separate narrow spatulate sepals, each grooved and nectar-bearing inside toward the base. Stamens 6, with linear anthers, which are much longer than the filaments. Style 3-cleft. Pod 3-lobed, 3-celled, few-seeded.

1. U. perfoliata L. MEALY BELLWORT. Leaves much as in the preceding species. Flowers very pale yellow, with shining grains on the inner surfaces of the twisted sepals; anthers sharp-pointed. Plant about two-thirds the size of the preceding.

2. U. grandiflora Sm. LARGER BELLWORT. Leaves oblong, with the base clasping the stem so as to make it appear to run through the leaf a little way from the base. Flowers greenish-yellow, 1½ in. long; anthers obtuse. A leafy plant, 1–2 ft. high.

V. OAKESIA Wats.

Plants with much the aspect of the preceding genus, but with merely sessile leaves, triangular winged pods, and slender, creeping rootstocks.

1. O. sessilifolia Wats. WILD OATS, STRAW LILIES. Stem slender, zigzag. Leaves lance-oval, thin, smooth, pale beneath, 1–1½ in. long. Flower cream color, nearly 1 in. long.

VI. ALLIUM L.

Herbs appearing stemless from coated bulbs with the characteristic odor of onions. Bulbs solitary or clustered. Leaves narrowly linear or slender-tubular, with a bloom. Flowers small, on slender pedicels, in terminal umbels on naked scapes, the umbels often bracted or inclosed in a spathe. Perianth 6-parted, persistent; stamens 6, somewhat perigynous, filaments filiform or dilated below. Ovary sessile, 3-celled; style thread-like, jointed; stigma entire. Fruit a 3-celled, 3-valved, few-seeded capsule. Flowers sometimes changed into bulblets.*

1. A. reticulatum Don. Resembling *A. Nuttallii*, but with larger bulbs. Leaves narrowly linear. Scape slender; bracts usually 2, taper-pointed; pedicels slender, ¼–½ in. long. Flowers white or pink; segments of the perianth thin. Capsule crested. W.

2. A. Nuttallii Wats. Bulbs ovoid, their coats with a fibrous network. Leaves basal, narrowly linear. Scape 4–8 in. high; bracts

3 or 2; pedicels $\frac{1}{3}$–$\frac{1}{2}$ in. long. Flowers rose color or white, the segments of the perianth becoming rigid in the fruit. On prairies W. and S.W.

3. A. canadense L. Meadow Garlic. Bulbs ovoid, the outer coats of white and thin, dry, netted fibers. Leaves narrowly linear, flat, or concave above. Scape cylindrical, 1 ft. high. Bracts of the umbel 2–3, ovate, acuminate; umbel consisting mostly of sessile bulblets. The few flowers long-pediceled, rose-colored. Perianth about as long as the stamens. Filaments dilated below. Capsule shorter than the perianth, 6-toothed, ovules 2 in each cell. On moist soil.*

4. A. mutabile Michx. Wild Onion. Bulbs ovoid, their coats with a very prominent fibrous network. Leaves basal, channeled, narrowly linear. Scape 1–2 ft. high, bracts taper-pointed, pedicels almost 1 in. long. Umbel rarely bearing bulblets. Flowers pink, rose color, or white; segments of the perianth thin. In moist soil S. and W.

5. A. vineale L. Field Garlic. Bulb mostly solitary. Leaves cylindrical, hollow, very slender. Scape slender, sheathed below the middle by the bases of the leaves. Umbels often crowded with bulblets. A troublesome weed in moist meadows and fields eastward, giving milk a strong flavor of onions or garlic. Naturalized from Europe.

VII. NOTHOSCORDUM Kunth

Scape-bearing herbs resembling *Allium,* but with no odor of onions. Flowers yellow or yellowish-green, in a loose, erect umbel, with 2 bracts.

1. N. bivalve Britton. Bulb small, often with little bulbs at its base. Leaves narrowly linear. Scape not exceeding 1 ft. high, the umbel 2-bracted, pedicels thread-like, at length 1–2 in. long. Flowers $\frac{1}{2}$ in. long or less, the perianth segments narrowly oblong, thin. On prairies and in open woods.

VIII. HEMEROCALLIS L.

Perennial, from a fascicle of fleshy roots. Stem erect, branched, smooth. Leaves mostly basal and linear. Flowers on branching scapes, large, yellow or orange, solitary or corymbed. Perianth funnelform, with a spreading limb much longer than the tube. Stamens 6, inserted in the top of the tube, shorter than the lobes, curved upward. Ovary 3-celled, many-ovuled; style longer than the stamens, curved upward; stigma knobbed. Fruit a 3-celled, 3-angled capsule.*

1. **H. fulva** L. Day Lily. Scapes stout, branched above, with a few bract-like leaves, smooth, 3–5 ft. high. Leaves very long, strap-shaped, acute, channeled. Flowers short-pediceled, tawny-yellow; perianth lobes oblong, netted-veined, lasting only one day. Introduced from Asia and common in old gardens.*

IX. LILIUM L.

Perennial, from scaly bulbs; stem erect, leafy, usually tall and slender. Leaves sessile, scattered or whorled. Flowers large, erect or drooping. Perianth corolla-like, deciduous; segments 6, spreading or recurved above, sessile or clawed, each with a nectar-bearing groove near the base. Stamens 6, elongated; anthers linear, versatile. Ovary 3-celled, many-ovuled; style long and slender; stigma 3-lobed. Fruit a 3-celled, dehiscent, many-seeded capsule.

1. **L. longiflorum** Thunb. Long-Flowered White Lily. Stem 1–3 ft. high. Leaves thick, lanceolate, scattered. Flower single, pure white, funnel-shaped, 5–6 in. long. Var. **eximium**, the Easter lily, bears several very showy and sweet-scented flowers. Cultivated from China and Japan.

2. **L. philadelphicum** L. Wild Red Lily. Stem 2–3 ft. high. Leaves linear-lanceolate, the upper ones generally whorled. Flower usually solitary (sometimes 2 or 3), erect, reddish-orange, with tawny or purplish spots inside. Sepals with claws. Dry or sandy ground, borders of thickets, etc.

Var. **andinum** Ker. Western Red Lily. Stem rather slender. Leaves linear, all alternate or the upper ones whorled. Flowers 1–3, erect. Segments of the perianth red, orange, or yellow, spotted beneath, the claw shorter than the blade. In dry soil W.

3. **L. canadense** L. Wild Yellow Lily, Meadow Lily. Stem 2–5 ft. high. Leaves lanceolate, 3-nerved, the margins and nerves roughish with short hairs, whorled. Flowers usually 3, sometimes more numerous, all nodding, on peduncles 3–6 in. long, yellow or orange, with dark purple or brown spots inside. Sepals without claws, recurved. Moist meadows and borders of woods.

X. FRITILLARIA L.

Leafy-stemmed perennials, from scaly or coated bulbs. Flowers single or several, nodding. Perianth bell-shaped, a nectar-bearing spot above the base of each division. Stamens as long as the petals.

1. **F. Meleagris** L. GUINEA-HEN FLOWER. Stem 1 ft. high. Leaves linear, alternate, channeled. Flower usually single, large, purplish, checkered with blue and purple or yellow. Cultivated from Europe.

2. **F. imperialis** L. CROWN IMPERIAL. Stem 3–4 ft. high. Leaves abundant in whorls about the middle or lower part of the stem, lanceolate or lance-oblong. Flowers several, large, yellow or red, in an umbel-like cluster beneath the terminal crown of leaves. Cultivated from Europe.

XI. ERYTHRONIUM L.

Nearly stemless herbs, arising from rather deeply buried bulbs. Leaves 2, long and smooth, with underground petioles. Scape arising from between the bases of the leaves. Flower commonly single, nodding.

1. **E. americanum** Ker. YELLOW ADDER'S-TONGUE. Leaves mottled. Flowers handsome. Perianth light yellow. Style club-shaped; stigmas united.

2. **E. albidum** Nutt. WHITE DOGTOOTH VIOLET. Leaves not much mottled. Perianth bluish-white. Stigmas 3, short and spreading.

XII. TULIPA L.

Herbs appearing stemless, from coated bulbs. Leaves sessile. Scape simple. Flower solitary, erect. Perianth bell-shaped. Stamens short, awl-shaped, with broadly linear anthers. Style short; stigma thick, 3-lobed; ovary and pod triangular.

1. **T. Gesneriana** L. COMMON TULIP. Leaves 3–6, ovate-lanceolate, close to the ground. Flower large, on a smooth peduncle, color red, yellow, white, or variegated. Cultivated from Asia Minor. Many garden varieties exist.

XIII. SCILLA L.

Perennial herbs, appearing stemless, from coated bulbs. Leaves linear. Flowers racemed on a scape, generally blue. Divisions of the perianth 1-nerved, parted almost to the base. Filaments 6, often broad at the base. Style slender, with a knob-like stigma. Ovary 3-angled, 3-celled.

1. **S. sibirica** Andr. SIBERIAN SQUILL. Scapes 3–8 in. high, several from each bulb, 2–3-flowered. Leaves 2–4, narrowly strap-shaped. Flowers intense blue, short-peduncled, often nodding. Cultivated from Russia and Siberia.

XIV. CAMASSIA Lindl. (QUAMASIA)

Herbs appearing stemless, from coated bulbs. Leaves linear. Flowers racemed on a scape. Perianth of 6 blue or purple spreading sepals. Stamens with thread-like filaments, slightly perigynous. Style thread-like, ending in a knobbed stigma. Capsule 3-angled, 3-celled, several-seeded.

1. **C. esculenta** Robinson. WILD HYACINTH. Leaves keeled, weak, shorter than the scape. Flowers in a long-bracted raceme, pale blue. River bottoms and other damp, rich soil.

XV. ORNITHOGALUM L.

Herbs appearing stemless, from coated bulbs. Leaves linear, fleshy. Scape erect. Flowers in corymbs or racemes, bracted. Perianth segments 6, white, nerved, persistent. Stamens 6, hypogynous, slender; filaments flattened. Ovary sessile, 3-celled, few-ovuled. Fruit a roundish, 3-angled capsule, seeds black.*

1. **O. umbellatum** L. STAR OF BETHLEHEM. Bulb ovoid, membranous-coated. Leaves numerous, linear, fleshy; mid-vein nearly white, as long as the scape. Scape slender, 6–12 in. high. Flowers opening in sunshine, long-pediceled. Bracts linear-lanceolate, about as long as the pedicels. Perianth segments oblong-lanceolate, white with a green stripe on the back, twice the length of the stamens. Introduced from Europe; very common about old gardens.*

XVI. HYACINTHUS L.

Herbs appearing stemless, from coated bulbs. Leaves linear, fleshy. Flowers in an erect spike, pediceled, bracted. Perianth tubular below, lobed and spreading above. Stamens short, included. Style short; stigma knobbed; ovary 3-celled, many-ovuled.*

1. **H. orientalis** L. HYACINTH. Leaves lance-linear, thick and fleshy, smooth. Scape erect, many-flowered. Segments united about half their length, white, blue, or red. Filaments very short. Ovary rarely maturing seed. Common in cultivation.*

XVII. YUCCA L.

Plants with woody and leafy stems. Leaves numerous, rigid, spine-pointed, persistent. Flowers in large terminal racemes or panicles, bracted, nodding. Perianth bell-shaped; segments 6, nearly alike, deciduous. Stamens 6; filaments thickened above, often papillose; anthers small. Ovary sessile, 3-celled or becoming 6-celled, 3-angled, many-ovuled. Fruit an oblong, 3-angled, many-seeded, dehiscent capsule, or fleshy and indehiscent.*

1. **Y. glauca** Nutt. BEAR GRASS, SOAP WEED. Stem very short. Leaves basal, long, straight and slender, stiff, sharp-pointed, the margins white and with a few thread-like filaments, $\frac{1}{4}$–$\frac{1}{2}$ in. wide. Flowers racemed, greenish-white, globose or oblong, bell-shaped. Style green; capsule large, oblong, six-sided. Dry soil W.

2. **Y. filamentosa** L. SPANISH DAGGER. Stem stout, 4–12 in. high. Leaves linear or linear-lanceolate, slender-pointed, narrowed above the spreading and clasping base, spreading or recurved, smooth, with loose, thread-like filaments on the margins. Panicle elongated, with bract-like leaves on the scape, widely branched, downy-hairy above, 3–6 ft. high. Perianth white, bell-shaped, 2 in. wide. Capsule oblong, angles rounded, sides furrowed, at length 3-valved and dehiscent. In sandy soil, and often cultivated for ornament.*

XVIII. ASPARAGUS L.

Stem from fleshy, fibrous roots, erect, branched; branches slender, with thread-like branchlets in the axils of scales which take the place of leaves. Flowers small, solitary or racemed. Perianth 6-parted; segments distinct or slightly united. Stamens 6, perigynous; filaments thread-like. Ovary 3-celled, 6-ovuled; style short, slender; stigmas 3, recurved. Fruit a berry.*

1. **A. officinalis** L. ASPARAGUS. Stem succulent and simple, with fleshy scales when young; becoming taller, more woody, and widely branched, when old. Flowers axillary, solitary, or 2 or 3 together on slender, jointed, drooping pedicels, greenish; segments linear. Berry red, few-seeded. Introduced from Europe, common in cultivation, and often escaped.*

XIX. SMILACINA Desf. (VAGNERA)

Perennial, simple-stemmed herbs, with rootstocks. Leaves usually sessile, nerved, alternate. Flowers white, in a terminal raceme. Perianth spreading, 6-parted. Stamens 6, somewhat perigynous; filaments slender; anthers short, facing inward.

Ovary 3-celled, 6-ovuled; style short and stout, with a somewhat 3-lobed stigma. Fruit a 1–2-seeded berry.

1. **S. racemosa** Desf. FALSE SPIKENARD. A showy plant with curved stem 1–3 ft. high, downy throughout. Leaves abundant, oval or ovate-lanceolate, taper-pointed. Flowers small, in a compound raceme. Berries pale red, speckled with dark red or purple. Moist thickets.

2. **S. stellata** Desf. Plant 1 ft. or less in height, nearly smooth. Leaves broadly lanceolate, acute, clasping. Flowers few, larger than in No. 1, in a simple raceme. Berries very dark red. Along river banks.

XX. MAIANTHEMUM Wiggers. (UNIFOLIUM)

Stem low. Leaves 2–3, lanceolate or ovate, with a heart-shaped base. Flowers small, white, solitary or in a simple raceme. Perianth 4-parted. Stamens 4. Ovary 2-celled; stigma 2-lobed.

1. **M. canadense** Desf. TWO-LEAVED SOLOMON'S SEAL, WILD LILY OF THE VALLEY. Plant 3–6 in. high. Leaves very short-petioled. Fruit a globular or ovoid berry, whitish, with brownish-red blotches. Woods and shaded banks N.

XXI. STREPTOPUS Michx.

Herbs with forking stems from a creeping rootstock. Leaves clasping. Flowers small, borne singly or in pairs on peduncles which arise above the leaf axils and which are sharply bent or twisted near the middle. Anthers arrow-shaped. Ovary 3-celled, ripening into a red, many-seeded berry.

1. **S. amplexifolius** DC. LIVER BERRY. Stem smooth, 2 ft. or more high. Leaves smooth-margined. Flowers greenish-white. Damp woods.

2. **S. roseus** Michx. LIVER BERRY, JACOB'S LADDER. Branches with a few bristly hairs. Lower leaves margined with fine bristles. Flowers reddish or purplish. Cold, damp woods N.

XXII. POLYGONATUM Hill. (SALOMONIA)

Rootstock creeping, jointed, scarred. Stems simple, erect, scaly below, leafy above. Leaves alternate, oval or oblong. Flowers on axillary, 1–4-flowered, drooping, jointed peduncles.

Perianth tubular, 6-cleft. Stamens 6, included, inserted about the middle of the tube; anthers arrow-shaped. Ovary 3-celled, many-ovuled; style slender; stigmas knobbed or 3-lobed. Fruit a few-seeded berry.*

1. **P. biflorum** Ell. HAIRY SOLOMON'S SEAL. Stem simple, erect, arched, nearly naked below, 1–2 ft. high. Leaves 2-ranked, sessile or clasping, 3–7-nerved, smooth above, pale and downy beneath. Peduncles short, 1–4, often 2-flowered. Perianth greenish, 1–2 in. long. Filaments thread-shaped, roughened. Berry dark blue. Shady banks.*

2. **P. commutatum** Dietrich. SMOOTH SOLOMON'S SEAL. Stem simple, stout, curving above, 3–8 ft. high. Leaves lanceolate to ovate, many-nerved, partly clasping, smooth on both sides. Peduncles nearly half as long as the leaves, 2–6-flowered. Perianth greenish-yellow, ¾ in. long. Filaments smooth. Berry blue, ½ in. in diameter. In rocky woods and along streams.*

XXIII. CONVALLARIA L.

Low, smooth, apparently stemless, perennial herbs. Leaves 2, oblong, with long petioles, from a slender, creeping rootstock. Scape slender, angled, inclosed at the base by the leafstalks. Flowers racemed, white, drooping. Perianth bell-shaped, with recurved lobes. Stamens borne on the base of the perianth. Ovary 3-celled, ripening into a few-seeded red berry.

1. **C. majalis** L. LILY OF THE VALLEY. A familiar garden flower, cultivated from Europe, and also found wild in mountain woods from Virginia to Georgia.

XXIV. TRILLIUM L.

Low herbs, with the stem springing from a short rootstock. Leaves 3, large, netted-veined, in a whorl. Flower large, terminal. Perianth of 6 parts, the 3 sepals unlike the 3 petals in color and in texture. Stamens 6, with the linear anthers usually opening inward, longer than the filaments. Stigmas 3, sessile, spreading at the tips; ovary 3- or 6-angled, 3-celled, many-seeded. Fruit a roundish, many-seeded purple berry.

1. **T. sessile** L. Rootstock erect or ascending, corm-like. Stem slender, 1–8 in. high. Leaves broadly oval, obtuse or acute at the apex, rounded and sessile at the base, 3–5-nerved, smooth, bright

green, not mottled. Flowers sessile; sepals lanceolate, $\frac{2}{3}$–1 in. long: petals purple, elliptical, about the length of the sepals. Stamens half the length of the petals. Styles elongated, straight. In rich woods.*

2. T. erectum L. SQUAWROOT, BENJAMIN. Rootstock rather upright, large and stout. Leaves broadly diamond-shaped, tapering to a short point. Pedicel 1–3 in. long, not quite erect. Petals ovate to lanceolate, much broader than the sepals, of a rich brownish-purple or sometimes white or pale. Stigmas distinct, stout, and spreading. The disagreeable scent of the flower has given rise to several absurd popular names for it. In rich woods.

3. T. grandiflorum Salisb. LARGE-FLOWERED WAKE-ROBIN. Rootstock horizontal, stem slender, 12–18 in. high. Leaves rhombic-ovate, taper-pointed at the apex, rounded and sessile or slightly peduncled at the base, smooth and with a bloom, 5–7-nerved, bright green. Peduncle longer than the erect or slightly declined flower. Sepals lanceolate-acute, 1–1$\frac{1}{2}$ in. long. Petals white, fading to pink, longer than the sepals. Stamens less than half the length of the petals. Style short; stigmas recurved. Fruit a black, roundish berry. In rich woods.*

4. T. cernuum L. NODDING TRILLIUM. Stem 8–20 in. high. Leaves broadly rhombic or rhombic-ovate, 2–4 in. wide, taper-pointed, sessile or nearly so. Peduncle recurved beneath the leaves. Petals white or pink, wavy, somewhat recurved, as long as the sepals or a little longer. Stamens with filaments about equaling the anthers. Stigmas stout, recurved. Rich moist woods.

5. T. nivale Riddell. DWARF WHITE TRILLIUM. Stem 2–4 in. high. Leaves petioled, oval to ovate. Flower white, erect. Petals $\frac{1}{2}$–1$\frac{1}{4}$ in. long, ovate-spatulate. Rich, damp woods, blooming with the very earliest spring flowers.

6. T. undulatum Willd. PAINTED TRILLIUM. Stem 8–12 in. high. Rootstock oblique to the rest of the stem, rather small; roots long and fibrous. Leaves ovate, taper-pointed. Petals white, penciled at the base, with purple stripes, lance-ovate, somewhat recurved, wavy. Cold woods, especially N.

XXV. SMILAX L.

Mostly woody vines, usually with prickly stems, climbing by tendrils. Rootstock often large and tuberous. Leaves alternate, prominently nerved, netted-veined, petioled; stipules replaced by persistent tendrils. Flowers regular, diœcious, small, greenish, in axillary umbels. Perianth bell-shaped, segments 6. Stamens 6, distinct. Ovary 3-celled, 3–6-ovuled; stigmas 1–3, sessile or nearly so. Fruit a 1–6-seeded globose berry.

1. S. herbacea L. Carrion Flower. Stem herbaceous, erect, simple or branched, not prickly, 1–3 ft. high. Leaves few, ovate, acute, and mucronate at the apex, somewhat heart-shaped at the base, 5–7-nerved, thin, smooth above, downy below, the upper sometimes whorled and the lower bract-like; petiole short. Peduncles as long as the leaves, growing from below the petiole. Umbel many-flowered, flowers carrion-scented. Berry blue-black, 2–4-seeded. Dry, fertile soil.*

2. S. Walteri Pursh. Green-Brier. Stem low, with few prickles, 2–5 ft. long; branches slightly 4-angled, unarmed. Leaves oblong-lanceolate to oval, obtuse or acute at the apex, rounded or cordate at the base, 5-ribbed, smooth. Peduncles flattened, about as long as the petioles and pedicels. Berry bright red, ripening the first year. Wet pine barrens.*

3. S. rotundifolia L. Green-Brier, Cat-Brier, Dog-Brier, Horse-Brier, Wait-a-Bit. Stem green, strong; branchlets, and sometimes the branches, 4-angled, armed with stout hooked prickles. Leaves ovate or round-ovate, with a slightly heart-shaped base and an abruptly pointed tip. Berries black, with a bloom. Thickets, the commonest species N. E.

4. S. glauca Walt. Green-Brier. Stem cylindrical, slender, with scattered prickles, branches angled and usually without prickles. Leaves ovate or subcordate, pointed at the apex, mostly 5-nerved, smooth, white beneath, with a bloom, margin entire. Peduncle flattened, 2–3 times as long as the petiole, few-flowered. Berry black, 3-seeded. Margin of swamps.*

5. S. Bona-nox L. Bamboo Vine. Stem stout, cylindrical or slightly angled, scurfy when young, armed with numerous stout prickles. Branches 4-angled, usually unarmed. Leaves triangular, ovate, or often halberd-shaped, 5–7-ribbed, smooth on both sides and often discolored; margins usually fringed with fine prickles. Peduncles twice as long as the petioles, flattened. Umbels many-flowered; pedicels short. Berries 8–20 in a cluster, black, 1-seeded. In swamps and thickets.*

11. AMARYLLIDACEÆ. Amaryllis Family

Mostly smooth perennial herbs, from bulbs. Leaves basal, with no distinction between petiole and blade. Flowers borne on a scape, nearly or quite actinomorphic. Stamens 6. Style 1. Limb of the 6-parted, corolla-like perianth epigynous. Ovary 3-celled. Capsule 3-celled, several–many-seeded.

I. NARCISSUS L.

Scapes with 1–several flowers from a thin, dry spathe. Flowers with a cup-shaped or other crown on the throat of the perianth; tube of the perianth somewhat cylindrical, the 6 divisions of the limb widely spreading. Stamens 6, inserted in the tube.

1. **N. Psuedo-Narcissus** L. DAFFODIL, DAFFY, EASTER FLOWER. Scape short, bearing 1 large yellow flower; tube of perianth short and wide, crown with a crimped margin. Cultivated from Europe.

2. **N. Tazetta** L., var. **orientalis.** CHINESE SACRED LILY. Bulb large, often with many smaller ones attached to its base. Scape 1 ft. or more high. Flowers several, umbeled, fragrant. Perianth white or nearly so, the crown rather spreading, finely scalloped, yellow or orange. Cultivated from China.

3. **N. poeticus** L. POET'S NARCISSUS. Scape 1-flowered. Perianth pure white, the crown very narrow, edged with pink. Cultivated from S. Europe.

II. ZEPHYRANTHES Herb. (ATAMOSCO)

Stemless, from a coated bulb. Leaves linear, fleshy. Scape erect, 1–few-flowered. Flowers large, erect, or declined, subtended by a 1–2-leaved spathe. Perianth 6-parted, naked in the throat; tube short, segments petal-like, spreading. Stamens free, anthers versatile. Ovary 3-celled, many-ovuled; style elongated, declined; stigma 3-cleft. Fruit a many-seeded, 3-valved capsule; seeds black, compressed, or angled.*

1. **Z. Atamasco** Herb. ATAMASCO LILY. Bulbs about 1 in. in diameter. Leaves narrow, concave above, smooth, usually longer than the scape. Scape 6–12 in. high, 1-flowered. Spathe 1-leaved, 2-cleft. Flowers 2–3 in. long, white, tinged with pink or purple, bell-shaped, short-peduncled. Stamens longer than the tube, shorter than the style. Capsule depressed-globose, seeds angled. In rich, damp soil, often cultivated.*

III. HYPOXIS L.

Small, apparently stemless herbs. Leaves grass-like, hairy, from a solid bulb. Scapes thread-like, few-flowered. Perianth 6-parted, wheel-shaped, the 3 outer divisions greenish on the outside, the whole perianth withering on the pod. Seeds numerous.

1. **H. hirsuta** Coville. STAR GRASS. Leaves longer than the scape, both sparsely set with long, soft hairs. Scape 3–8 in. high. Flowers 1–4, about ½ in. across, yellow. Common in meadows and dry woods.

12. IRIDACEÆ. IRIS FAMILY

Perennial herbs from bulbs, corms, or rootstocks. Leaves 2-ranked, equitant. Flowers bisexual, often actinomorphic, each subtended by two bracts. Perianth 6-parted, the segments epigynous in 2 series of 3 each, equal, or the inner ones smaller. Stamens 3, distinct or united, opposite the outer segments. Ovary forming a 3-celled, 3-angled, 3-valved, many-seeded, dehiscent capsule.*

I. CROCUS L.

Leaves springing from the corm. Flowers sessile on the corm. Tube of the perianth very long and slender, its divisions all alike or nearly so. Stigmas 3-cleft.

1. **C. vernus** All. SPRING CROCUS. Leaves linear. Stigmas short. Flowers white, blue, or purple. Our earliest garden flower. Cultivated from Europe.

II. IRIS L.

Rootstock thick, creeping, branching, horizontal, sometimes tuberous. Stems erect, simple or branched. Leaves linear or sword-shaped. Flowers showy, the outer perianth segments spreading or recurved, often bearded within, the inner segments usually smaller and erect. Stamens inserted in the base of the outer segments. Style deeply 3-parted (Fig. 8), the divisions broad and petal-like, covering the stamens. Fruit an oblong or oval, 3- or 6-angled, many-seeded capsule (Fig. 9).*

1. **I. versicolor** L. LARGE BLUE FLAG. Rootstock thick, horizontal. Stem cylindrical, smooth, simple or branched, leafy, 2–3 ft. high. Leaves linear, sword-shaped, finely nerved, with a bloom, the lower 1½–2 ft. long, the upper shorter. Bracts longer than the pedicels. Flowers terminal, single or few together, blue variegated with white, yellow, and purple; perianth segments not bearded, the inner ones smaller. Ovary 3-angled, longer than the inflated perianth tube. Capsule oblong, slightly lobed; seeds 2 rows in each cell. In wet places.*

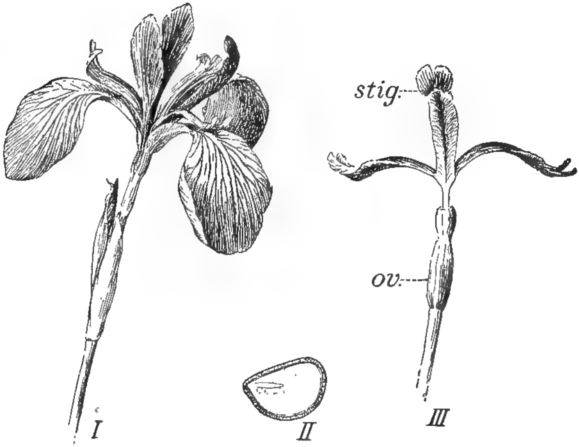


FIG. 8. Iris

I, flower. II, seed, longitudinal section. III, flower with outer segments of perianth removed: *stig.*, stigma, *ov.*, ovary

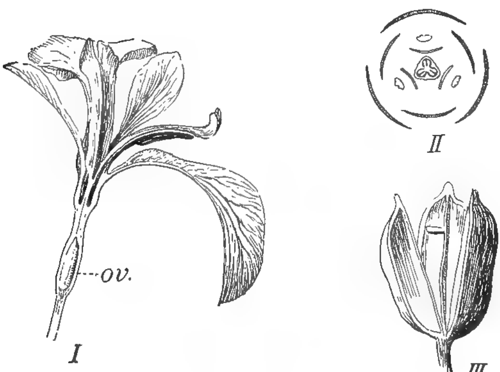


FIG. 9. Iris

I, flower, longitudinal section: *ov.*, ovary. II, diagram showing stigmas opposite the stamens; III, capsule, splitting between the partitions

2. I. prismatica Pursh. SLENDER BLUE FLAG. Rootstock rather slender, with tuber-like thickened portions. Stem slender, cylindrical, usually unbranched, 1–3 ft. high. Leaves 2–3 in number, narrowly linear, $\frac{1}{6}$–$\frac{1}{4}$ in. wide. Flowers slender-peduncled, solitary or in twos, blue with yellow veins, the perianth tube beardless and crestless. Ovary 3-angled; capsule sharply 3-angled. Marshy soil near the coast.

3. I. fulva Ker. YELLOW FLAG. Rootstock fleshy. Stem simple or branched, grooved, 1-angled below, bearing 2–3 leaves, 2–3 ft. high. Leaves linear, sword-shaped, with a bloom, shorter than the stem; bracts small. Pedicels short, flowers axillary and terminal, dull yellow or reddish-brown, variegated with blue and green, perianth segments not bearded. Style branches but little exceeding the stamens; ovary about as long as the inflated perianth tube; capsule ovate, 6-angled. Swamps and wet places.*

4. I. germanica L. FLEUR-DE-LIS. Rootstock thick, matted. Stem stout, branched, leafy, 2–3 ft. high. Leaves strap-shaped, acute, erect, shorter than the stem; bracts scarious. Flowers sessile, large and showy, blue variegated with white and yellow, sometimes nearly all white; outer segments large, recurved, bearded, the inner narrower, erect, or arched inward. Introduced from Europe; common in gardens and naturalized in many places.*

III. SISYRHINCHIUM L.

Small, grass-like perennials. Stems erect, flattened, or winged. Roots fibrous. Leaves linear or lanceolate. Flowers small, blue, quickly withering, in terminal 2-bracted umbels. Perianth corolla-like, of 6 bristle-pointed segments; tube nearly or wholly lacking. Stamens 3, completely monadelphous. Stigmas 3, thread-like. Fruit a nearly globular, 3-angled capsule. Species too difficult for the beginner; all commonly known as Blue-Eyed Grass.

13. ORCHIDACEÆ. ORCHIS FAMILY

Perennial herbs with simple stems, often arising from bulbs or tubers. Leaves simple, usually alternate and entire. Flowers bisexual, generally showy, epigynous, zygomorphic, and often of extraordinary shapes. Perianth of 6 divisions. Stamens 1 or 2, united with the pistil; pollen of comparatively few grains, held together in masses by cobweb-like threads. Ovary 1-celled, containing many (sometimes more than a million) very minute ovules.

The family is a difficult one, and most of the genera are so rare that specimens should not be collected in large numbers for class study. Two of the most familiar genera are *Cypripedium*, or Lady's Slipper, and *Spiranthes*, or Lady's Tresses. Many of the genera are tropical air plants.

SUBCLASS II. DICOTYLEDONOUS PLANTS

Stems composed of bark, wood, and pith; the fibro-vascular bundles in rings; in woody stems which live over from year to year, the wood generally in annual rings, traversed at right angles by medullary rays. Leaves netted-veined. Parts of the flower usually in fours or fives. Cotyledons 2 (rarely none).

14. SALICACEÆ. Willow Family

Diœcious trees or shrubs, with flowers in catkins, destitute of floral envelopes. Fruit a 1-celled pod, with numerous seeds, provided with rather long and silky down, by means of which they are transported by the wind.

I. SALIX L.

Shrubs or trees, branches usually very slender. Buds with single scales. Leaves usually long and narrow; stipules sometimes leaf-like or often small and soon deciduous. Bracts of the catkins entire. Staminate catkins erect or drooping (Fig. 10); staminate flowers with 2–10, mostly 2, distinct or united stamens. Pistillate catkins usually erect (Fig. 10); flowers with a small gland on the inner side of the bract; stigmas short, 2-lobed. Capsule 2-valved.*

[Thirty or more species of willow are found growing wild in the northeastern and north central states, but they are very hard, even for botanists, to identify.]

1. S. nigra Marsh. BLACK WILLOW. A small tree with very brittle branches. Leaves elliptical or narrowly lanceolate, acute at each end, serrate, short-petioled, downy when young and becoming smooth with age, 2–3 in. long; stipules persistent or deciduous. Staminate catkins 1–2 in. long; the pistillate 2–4 in. long. Stamens 3–7, distinct; filaments soft-hairy below. Capsule twice the length of the pedicel, ovate, taper-pointed, pointed by the prominent style. Along streams and borders of marshes.*

2. S. lucida Muhl. SHINING WILLOW. A large shrub or sometimes a bushy tree 20 ft. high, with smooth bark, yellowish-brown and shining on the twigs. Leaves varying from ovate to lanceolate, usually with very slender tapering points, sharply and finely serrate, firm, green, and glossy on both sides, 3–5 in. long; stipules small, oblong, usually persistent. Catkins borne on short leafy branches, the staminate ones stout, 1–1½ in. long, the pistillate ones slender, 1½–2 in. long, lengthening in fruit to 3–4 in. Stamens usually 5. Capsule narrowly ovoid or cylindrical, pointed, smooth, and shining. Banks of streams, lakes, and swamps. One of the most beautiful willows from the showiness of the staminate catkins and the large glossy leaves.

FIG. 10. White willow (*Salix alba*)

A, staminate catkin, natural size; *B*, pistillate catkin, natural size; *C*, a staminate flower, magnified; *D*, a pistillate flower, magnified. (After Cosson and De Saint-Pierre)

3. S. alba L. WHITE WILLOW, YELLOW WILLOW. A spreading tree 50–80 ft. high, with rough gray bark, yellowish-green on the twigs. Leaves lanceolate, narrowed at the base, with long tapering points, gray or silky-downy on both sides when young, the upper surface (especially in Var. *vitellina*) becoming smooth when old, 2–4 in. long; stipules ovate-lanceolate, deciduous. Catkins on short leafy branches, the pistillate ones slender, cylindrical, 1¼–3½ in. long. Stamens usually 2. Capsule ovoid, pointed. Cultivated from Europe (especially Var. *vitellina*), and occasionally escaped from cultivation along streams. Very variable and with many hybrids.

4. S. babylonica L. WEEPING WILLOW. A spreading tree, sometimes 60 ft. or more in height, with drooping branches. Leaves narrowly lanceolate, taper-pointed, serrate, slightly downy when young and becoming smooth with age, green above, pale beneath, often 5–7 in. long; petioles short, glandular. Catkins on short lateral branches. Stamens 2. Style almost none. Capsule sessile, smooth. Introduced and cultivated for ornament.

5. S. cordata Muhl. HEART-LEAVED WILLOW. A shrub 4–10 ft. high, with twigs finely downy or smooth. Leaves oblong-lanceolate, taper-pointed, finely and sharply serrate, often tapering but frequently obtuse or somewhat heart-shaped at the base, finely downy when young (especially on the midrib) but smooth when old; sometimes 5 in. long; stipules usually large and conspicuous, unequal-sided, finely serrate, generally persistent. Catkins with bracts at the base, opening earlier than the leaves, the staminate ones very silky, less than 1 in. long, the fertile ones in fruit $1\frac{1}{2}$–$2\frac{1}{2}$ in. long. Capsules narrowly ovoid, pointed. In wet soil and along streams, very variable and widely distributed.

6. S. discolor Muhl. GLAUCOUS WILLOW, PUSSY WILLOW. A low tree, sometimes 20 ft. or more in height, with light greenish-brown or reddish-brown bark. Leaves oblong-lanceolate, tapering at both ends, finely and irregularly toothed or nearly entire, on slender petioles, smooth and firm, bright green above, smooth or silvery white below, 3–5 in. long; stipules often leaf-like, unsymmetrical, usually deciduous. Staminate catkins very white and silky, oblong-cylindrical, 1 in. or more long, appearing much earlier than the leaves; pistillate catkins $1\frac{1}{2}$–$2\frac{1}{2}$ in. or more long. Stamens 2, with long, slender filaments. Capsule cylindrical or nearly so, long-beaked. Common in wet meadows or along streams and swamps.

II. POPULUS L.

Trees with prominent scaly buds, twigs more or less angled. Leaves usually long-petioled.

Flowers borne in long, drooping catkins, which appear before the leaves; scales of the catkins irregularly cut toward the tip. Stamens 8–30 or more. Stigmas 2–4. Capsules opening early by 2–4 valves.

1. P. alba L. SILVER-LEAVED POPLAR, WHITE POPLAR. A large tree, sometimes more than 100 ft. high, with smooth greenish-gray bark. Leaves broadly ovate, rhombic-oval or nearly orbicular, lobed or very coarsely toothed, densely white-downy beneath. Cultivated as a shade tree and sometimes found growing spontaneously.

2. P. tremuloides Michx. American Aspen, Quaking Asp. A tree 20–60 ft. high, with greenish-white bark. Leaves roundish, heart-shaped, abruptly pointed, with small regular teeth. Leafstalk long, slender, and flattened at right angles to the broad surfaces of the leaf, causing it to sway edgewise with the least perceptible breeze. Common especially N.

3. P. grandidentata Michx. Large-Toothed Poplar. A tree 60–80 ft. high, with rather smooth gray bark. Leaves 3–5 in. long, roundish-ovate and irregularly sinuate-toothed; when young completely covered with white silky wool, which is shed as soon as the leaf matures. The petiole is somewhat flattened, but not nearly as much so as that of the preceding species. Rich woods N.

4. P. heterophylla L. Swamp Poplar. Branches only slightly angled. Leaves ovate, mostly obtuse at the apex, rounded or subcordate at the base, serrate with obtuse teeth, densely woolly when young, but becoming smooth with age; petioles cylindrical. Pistillate catkins smooth, erect or spreading, loosely flowered. Capsule ovoid, usually shorter than the pedicel. Common in river swamps. A large tree with soft light wood, which is often used in making cheap furniture.*

5. P. deltoides Marsh. Cottonwood. A large and very rapidly growing tree, 75-100 ft. or more high, often with a markedly excurrent trunk. Leaves large and broadly triangular, with crenate-serrate margins and long, tapering, acute tips; petioles long and considerably flattened. The numerous pediceled capsules are quite conspicuous when mature, and the air is filled with the downy seeds at the time when the capsules open. Common W., especially along streams, and planted as a shade tree.

15. MYRICACEÆ. Bayberry Family

Shrubs with alternate, simple, resinous-dotted leaves; monœcious or diœcious. Flowers in short, bracted catkins; perianth none. Staminate flowers 2–10, stamens hypogynous; pistillate flowers surrounded by 2–6 scales. Ovary 1-celled; style short; stigmas 2.

I. MYRICA L.

Shrubs or small trees with the branches clustered at the end of the growth of the previous season. Leaves short-petioled, entire, lobed or toothed, the margin usually revolute, without stipules. Perianth none. Staminate flowers in oblong or cylindrical catkins; stamens 2–10, with the filaments united below. Pistillate flowers surrounded by a cup of 2–6 scales; ovary solitary, becoming a 1-celled, roundish drupe or nut, often covered with waxy grains. Whole plant usually fragrant.*

1. M. carolinensis Mill. WAXBERRY, BAYBERRY. A spreading shrub or small tree; young branches downy. Leaves lanceolate or oblong-lanceolate, entire or sometimes serrate near the mostly obtuse apex, smooth or downy on the veins beneath, tapering into a short petiole. Flowers mostly diœcious. Staminate catkins numerous, stamens 4. Pistillate catkins small, bracts slightly 3-lobed, scales of the ovary 4, fringed with hairs; stigmas 2. Fruit very abundant, incrusted with white wax, $\frac{1}{8}$–$\frac{1}{6}$ in. in diameter, sometimes persistent for 2 or 3 years. Common on wet soils, especially near the coast.*

2. M. asplenifolia L. SWEET FERN. A shrub 2 ft. or less in height, with brown twigs. Leaves fern-like, linear-lanceolate, 20–30-lobed, 3-5 in. long and very fragrant. Often monœcious. Staminate catkins cylindrical; pistillate catkins globular. Ovary surrounded by 8 long, linear, awl-shaped, hairy and glandular scales which encircle the ripened fruit. Nut nearly ovoid, smooth, small, but eaten by children.

16. JUGLANDACEÆ. WALNUT FAMILY

Trees with alternate, odd-pinnate leaves without stipules. Flowers monœcious, the staminate in long and drooping catkins; stamens few or many; calyx 2–6-parted. Fertile flowers solitary or in small clusters; calyx 3–5-lobed, minute petals sometimes present. Ovary inferior, 1-celled or incompletely 2–4-celled. Fruit (strictly speaking a drupe) with a dry husk inclosing a bony nut.*

I. JUGLANS L.

Staminate catkins cylindrical, solitary, borne on wood of the previous year; stamens numerous, filaments short; calyx 4–6-parted. Pistillate flowers single or a few together on a short peduncle at the base of the growth of the season. Calyx 4-parted. Petals 4, minute, epigynous. Styles 2, short, plumose. Fruit large, roundish or oval, husk fibrous-fleshy, becoming dry, indehiscent; nut bony, very rough.*

1. J. cinerea L. BUTTERNUT. Leaflets 15–19, ovate-lanceolate, taper-pointed at the apex, rounded or slightly unsymmetrical at the base, serrate, downy beneath; petioles, branchlets, and fruit clothed with short, sticky hairs. Fruit often somewhat in clusters, oblong, large. More common northward. Wood less valuable and nut less oily than the black walnut. The English walnut (*J. regia*) is occasionally seen in cultivation. It has 7–11 leaflets and a nearly smooth nut.*

2. J. nigra L. BLACK WALNUT. Leaflets 13–21, ovate-lanceolate, serrate, taper-pointed, somewhat cordate or oblique at the base, nearly smooth above, downy beneath; petioles minutely downy. Fruit usually single, roundish, about 2 in. in diameter. On rich soil, rare near the coast. One of the most valuable of our native trees, the wood being very durable and highly prized for cabinet work.*

II. CARYA Nutt. (HICORIA)

Leaflets serrate. Staminate catkins usually in threes on a common peduncle, or sometimes sessile at the base of the growth of the season; calyx 2–3-parted; stamens 3–10, filaments short. Pistillate flowers 2–5 in terminal clusters; calyx 4-parted; petals none; styles 2 or 4, fringed. Fruit somewhat globular, husk separating more or less completely into 4 valves; nut smooth or angled.*

1. C. illinoensis K. Koch. PECAN. A large tree with rough gray bark, young twigs and leaves downy, nearly smooth when mature. Leaflets 11–15, oblong-lanceolate, acuminate, serrate, scythe-shaped. Staminate catkins nearly sessile, 5–6 in. long. Husk of fruit thin; nut oval or oblong, thin-shelled. River bottoms. Rarely native east of the Mississippi River, but widely planted for its fruit.*

2. C. ovata K. Koch. SHELLBARK HICKORY. A large tree with bark scaling off in long plates; young twigs and leaves downy, becoming smooth with age. Leaflets 5, the lower ones oblong-lanceolate, the upper one longer and obovate, taper-pointed at the apex, narrowed to the sessile base. Inner bud scales becoming large and conspicuous. Staminate catkins in threes. Fruit globose, husk thick, splitting into four sections; nut white, compressed, 4-angled, pointed, thin-shelled. On rich soil; more common N. Wood strong and elastic, but not durable when exposed.*

3. C. laciniosa Loud. BIG SHELLBARK, KING NUT, BULL NUT. A tree 70–90 ft. high, with shaggy bark. Leaflets 7 or 9, the terminal one nearly sessile. Fruit large, ovoid or nearly so, 4-grooved toward the outer end, the husk very thick, nut pointed at each end, $1\frac{1}{2}$–2 in.

long, thick-shelled, with a very sweet kernel. Wood hard and heavy. Common in rich, damp soil W.

4. C. alba K. Koch. MOCKER NUT, WHITE-HEART HICKORY. A large tree 70–100 ft. high, with close, rough bark; catkins, twigs, and under surfaces of the leaves downy and resinous-scented when young. Leaflets 7–9, oblong-lanceolate or obovate-lanceolate, taper-pointed. Fruit globose or nearly so, with a very thick, hard husk; nut with 4 ridges toward the apex, very thick-shelled, with a small, sweet kernel. On rich hillsides. Wood much like that of *C. ovata.*

5. C. cordiformis K. Koch. PIGNUT, SWAMP HICKORY. A medium-sized tree, with rather smooth bark. Leaflets 7–11, lanceolate or oblong-lanceolate. Fruit not large, husk thin; nut globular, with a short point, very thin-shelled; kernel extremely bitter. Moist soil, common in the Middle States.

17. BETULACEÆ. BIRCH FAMILY

Trees or shrubs with alternate, simple, petioled leaves, with usually deciduous stipules. Flowers monœcious in cylindrical or subglobose catkins. Staminate catkins drooping; flowers 1–3 in the axil of each bract; calyx none or membranous and 2–4-parted; stamens 2–10, distinct. Pistillate catkins drooping, spreading, or erect and spike-like; flowers with or without a calyx; ovary solitary, 1–2-celled; ovules 1–2 in each cell. Fruit a 1-celled nut or a key.*

I. CORYLUS L.

Shrubs with prominently veined, cut-toothed leaves, which are folded lengthwise in the bud. Flowers expanding before the leaves. Staminate flowers in slender, drooping catkins; stamens 8, anthers 1-celled. Fertile flowers several in a cluster or in very short catkins at the ends of the twigs of the season; ovary incompletely 2-celled; style short; stigmas 2; bractlets 2, becoming enlarged and inclosing the single bony nut at maturity.*

1. C. americana Walt. HAZELNUT. A shrub 2–5 ft. high; young twigs and petioles covered with brownish, stiff hairs. Leaves not very thin, round-cordate, acute or slightly taper-pointed, irregularly toothed, nearly smooth above, downy below. Involucre longer than the nut and partially inclosing it, glandular-hairy. Nut subglobose, pointed, edible. On rich soil, borders of meadows and fields, and in oak openings.

2. C. rostrata Ait. Beaked Hazelnut. A shrub 4–8 ft. high. Young twigs near ends smooth. Leaves thin, little if at all heart-shaped, doubly serrate or incised, taper-pointed, stipules linear-lanceolate. Involucre completely covering the nut and prolonged into a beak beyond it. Common N. [The latter species is not nearly as widely distributed as the former; they cannot be readily distinguished from each other until the fruit is somewhat mature. The principal points of difference discernible before the fruit is nearly mature are the hairy twigs of No. 1 and the smooth ones of No. 2, and the fact that No. 1 has buds rounded at the apex and more slender and longer staminate catkins, while No. 2 has buds acute at the apex and thicker and shorter staminate catkins.]

II. OSTRYA Scop.

Small trees with gray bark and very hard wood. Leaves open and concave in the bud and somewhat plaited on the veins. Staminate flowers on slender, drooping catkins, sessile at the end of the growth of the previous season; stamens 3–12, subtended by a bract; filaments forked; anthers hairy. Pistillate flowers surrounded by a tubular bractlet, which becomes large and bladder-like at maturity. Fruit a small, pointed, smooth nut; mature catkins hop-like.*

1. O. virginiana K. Koch. A small tree with brownish, furrowed bark. Leaves ovate, acute, doubly serrate, often inequilateral at the base, short-petioled. Staminate and fertile catkins 2–3 in. long. In rich woods. Often known as "ironwood" and "leverwood." *

III. CARPINUS L.

Trees with thin, straight-veined leaves, which are folded in the bud. Flowers appearing before the leaves. Staminate flowers in slender, drooping catkins, sessile at the end of the growth of the previous season; stamens 3–12, subtended by a bract; filaments forked; anthers hairy. Pistillate catkins spike-like, each pair of flowers subtended by a deciduous bract, and each flower by a persistent bractlet, which becomes large and leaf-like in fruit; ovary 2-celled, 2-ovuled; stigmas 2, thread-like. Fruit a small, angular nut.*

1. C. caroliniana Walt. Hornbeam. A small tree with smooth and close gray bark; twigs slender. Leaves ovate-oblong, acute or taper-pointed, sharply and doubly serrate, the straight veins terminating in the larger serrations; downy when young and soon becoming smooth. Staminate catkins 1–1½ in. long. Pistillate catkins long-peduncled, 8–12-flowered; bractlets becoming nearly 1 in. long, cut-toothed, the middle tooth much longer than the others. In rich, moist woods. Often known as "blue beech" and "ironwood."*

IV. BETULA L.

Trees with slender, aromatic twigs, and thin, usually straight-veined leaves. Staminate catkins drooping, flowers usually 3 in the axil of each bract; stamens 4, short; anthers 1-celled. Pistillate catkins erect, flowers 2 or 3 in the axil of each bract; ovary sessile, 2-celled; styles 2; bracts 3-lobed; perianth none. Nut broadly winged.*

1. B. lenta L. Cherry Birch. Leaves ovate or oblong-ovate, acute, heart-shaped, finely and doubly serrate, silky when young; petioles about ½ in. long. Staminate catkins clustered, 3–4 in. long. Pistillate catkins sessile, about 1 in. long; cylindrical bracts spreading, acute, smooth. River banks, especially N. A large tree, with aromatic twigs. The oil contained in the bark and twigs is distilled and used as a substitute for wintergreen.*

2. B. lutea Michx. f. Yellow Birch. A large forest tree, sometimes 60–90 ft. high, with yellowish or silver-gray bark, which peels off in extremely thin layers. Leaves ovate or nearly so, usually taper-pointed, rounded or sometimes almost heart-shaped at the base, sharply and finely serrate, somewhat downy on the veins beneath, 3–5 in. long. Staminate catkins 3–3½ in. long; pistillate catkins about ⅔ in. long. Rich woods N., also southward in the mountains.

3. B. nigra L. River Birch, Red Birch. A medium-sized tree with reddish-brown bark. Leaves rhombic-ovate, acute at the apex, acute or obtuse at the base, sharply and doubly serrate, white-downy below, becoming smoother with age, petioles short. Staminate catkins 2–3 in. long. Pistillate catkins 1–1½ in. long, peduncles short, bracts nearly equally 3-cleft, woolly. River banks, especially S. and W.*

4. B. populifolia Marsh. Gray Birch. A tall shrub or slender, straggling tree, 15–30 ft. high, seldom growing erect, often several trunks springing from the ground almost in contact and slanting away from each other. Leaves triangular, with a long taper point and truncate base, unevenly twice serrate, with rather long, slender petioles, which allow the leaves to quiver like those of the aspen.

Bark scaling off in white strips and layers, but not in nearly as large sheets as that of the rarer canoe birch (*B. papyrifera*). The commonest birch of New England.

5. **B. alba** L. EUROPEAN WHITE BIRCH, CUT-LEAVED BIRCH. A tree 50–60 ft. high, often with drooping branches. Leaves triangular-ovate, truncate, rounded or somewhat heart-shaped at

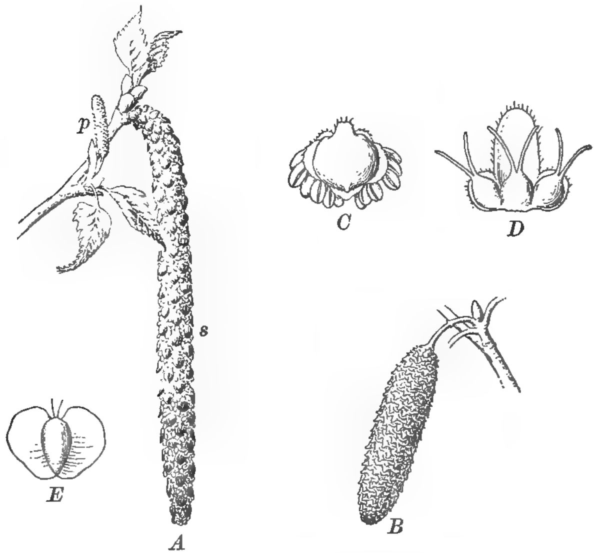


FIG. 11. Gray birch (*Betula populifolia*)

A, catkins, natural size: *s*, staminate; *p*, pistillate. *B*, cluster of ripened fruits; *C*, bract with three staminate flowers; *D*, bract with three pistillate flowers; *E*, fruit. (*B*, *C*, *D*, *E*, somewhat magnified)

the base, not strongly taper-pointed except in the cut-leaved form. Commonly cultivated from Europe. Resembles No. 4, but has whiter bark and (the weeping form) much more slender branches.

Var. **papyrifera.** CANOE BIRCH, PAPER BIRCH. A large tree, often 60–70 ft. high, with chalky-white papery bark, peeling off in large thin sheets. Leaves ovate, acute or taper-pointed, coarsely serrate or dentate, but entire at the base, dark green and usually without glands on the upper surface, on the lower surface light yellowish-green and nearly smooth, but with tufts of hairs in the forks of the veins and numerous black glands, 2–3 in. long, with slender petioles. Staminate catkins 3–4 in. long; pistillate catkins 1–1½ in. long, peduncles 2-bracted. Rich soil on hillsides, along streams, and near lakes and swamps, N. and N.E. The beautiful bark is much used by the Indians for canoes, for basket making, and for other purposes.

V. ALNUS Hill

Shrubs or small trees. Leaves petioled, serrate. Flower buds stalked, appearing the previous season; staminate catkins racemed, drooping; flowers 3–6 in the axil of each bract, subtended by 1–2 bractlets; perianth 4-parted; stamens 4; filaments short. Pistillate catkins erect; flowers 2–3 in the axil of each bract; perianth replaced by 2–4 minute bractlets which are adherent to the bract. Ovary 2-celled; styles 2. Fruit a winged or angled nut; bracts of the pistillate flowers somewhat fleshy, persistent, becoming woody in fruit.*

1. A. incana Mœnch. Speckled Alder. A shrub 8–20 ft. high. Leaves broadly oval or ovate, rounded at the base, sharply (sometimes doubly) serrate, white and usually downy beneath. Fruit round. Forming thickets by streams, very common N.

2. A. rugosa Spreng. Smooth Alder. A shrub or small tree with smooth bark. Leaves obovate, rounded or obtuse at the apex, acute at the base, sharply and minutely serrate, smooth above, downy beneath, petioled; stipules oval, deciduous. Staminate catkins 2–4 in. long; fruiting catkins ovoid, short-peduncled. Fruit ovate, wingless. Banks of streams and borders of marshes, ranging far S. Leaves often persistent during the winter.*

18. FAGACEÆ. Beech Family

Trees or shrubs. Leaves alternate, simple, pinnately veined; stipules deciduous. Flowers monœcious, the staminate in heads, or in drooping, spreading, or erect catkins; calyx minute; petals none; stamens 4–20. Pistillate flowers solitary or in small clusters, each flower subtended by more or less united bracts, which at maturity form a cup or bur; calyx minutely toothed; petals none; ovary 2–7-celled, but becoming 1-celled. Fruit a 1-seeded nut.*

I. FAGUS L.

Trees with smooth, close, ash-gray bark, and slender, often horizontal, branches. Staminate flowers in long, slender-peduncled, roundish clusters; calyx bell-shaped, 4–6-cleft; stamens 8–12; anthers 2-celled. Pistillate flowers solitary or more often in pairs, peduncled, surrounded by a 4-lobed involucre and numerous linear bracts; ovaries 3-celled, with 2 ovules in each cell, but usually only 1 ovule maturing in each ovary; styles 3, thread-shaped. Fruit a thin-shelled, 3-angled nut.*

1. **F. grandifolia** Ehrh. BEECH. Large trees. Leaves oblong-ovate, taper-pointed at the apex, serrate, straight-veined, very white-silky when young, nearly smooth with age. Involucre densely covered with short recurved spines. Nuts thin-shelled, edible. Common on damp soil everywhere. The wood is very hard, tough, and close-grained, and is especially valuable for the manufacture of small tools.*

2. **F. sylvatica** L. The European beech is occasionally found planted as a shade tree. The variety known as the copper beech is most usual, and is readily recognized by its dark, crimson-purple leaves.

II. CASTANEA Hill

Trees or shrubs with rough, gray, rather close bark. Leaves straight-veined, undivided, prominently toothed. Flowers appearing later than the leaves. Staminate catkins erect or spreading, loosely flowered, flowers several in the axil of each bract; calyx 4–6-parted; stamens 8–16. Pistillate flowers at the base of the staminate catkin or in small separate clusters, usually 3 in each involucre; ovary 4-celled, surrounded by 5–12 abortive stamens. Fruit a 1-celled nut inclosed in the greatly enlarged and very prickly involucre.*

1. **C. dentata** Borkh. AMERICAN CHESTNUT. A large tree, bark somewhat rough, and splitting into longitudinal plates. Leaves oblong-lanceolate, taper-pointed at the apex, usually acute at the base, coarsely and sharply serrate with ascending teeth, smooth, dark green above, lighter below; petioles stout, short. Staminate catkins erect, 6–10 in. long. Nuts usually 3 in each bur. Rich soil, especially N. Rarely found on soils containing much lime.*

2. **C. pumila** Mill. CHINQUAPIN. A small tree or shrub. Leaves oblong, acute or obtuse at both ends, serrate with divergent teeth, dark green and smooth above, white-woolly below. Nuts solitary, nearly globular. Common southward in rich woods.*

III. QUERCUS L.

Trees or shrubs with entire, serrate, or lobed leaves, which are often persistent. Staminate flowers in slender catkins, each subtended by quickly deciduous bracts, and consisting of 3–12 stamens inclosed by a 4–8-parted perianth, often containing an abortive ovary. Pistillate flowers solitary or in small clusters, each consisting of a 3-celled ovary with 2 ovules in each cell, though rarely more than 1 ovule matures; styles short, erect, or recurved. Pistillate flowers surrounded by a scaly involucre which at maturity becomes a cup inclosing the base of the fruit or sometimes a large part of it. Fruit an ovoid or subglobose, 1-seeded, thin-shelled nut (acorn).

A. Fruit annual; leaves not bristle-tipped, though often mucronate.

1. Q. alba L. White Oak. A large tree with light gray bark. Leaves obovate-oblong, 3–9-lobed, lobes rounded and mostly entire, bright green above, paler below, short-petioled. Cup hemispherical, scales rough, woolly when young, but becoming smooth with age; acorn oblong-ovate, about 1 in. long. Common in damp soil. Wood strong and durable; one of the most valuable timber trees.*

2. Q. stellata Wang. Post Oak. A tree of medium size with rough gray bark. Leaves broadly obovate, deeply lyrate-pinnatifid into 5–7 rounded, divergent lobes, upper lobes much the longer, smooth above, yellowish-downy beneath; petioles about 1 in. long. Cup hemispherical, nearly sessile; acorn ovoid, 2–3 times as long as the cup. On dry soil. Wood hard and valuable.

3. Q. lyrata Walt. Swamp Oak. A large tree with gray or reddish bark. Leaves obovate-oblong, deeply pinnatifid, lobes narrow, often toothed, thin, smooth above, white, densely woolly beneath. Cup round-ovate, scales cuspidate, inclosing nearly the whole of the depressed-globose acorn. On wet soil. Wood strong and very durable.*

4. Q. macrocarpa Michx. Bur Oak. A medium-sized to very large tree, with roughish gray bark. Leaves obovate or oblong, lyrately and deeply sinuate-lobed, smooth above, pale and downy beneath. Cup very deep and thick, abundantly fringed about the margin, $\frac{3}{4}$–2 in. in diameter. Acorn, half or more (sometimes entirely) inclosed by the cup. Reaches its full size only on rich bottom lands S. and W., where it becomes one of the finest timber oaks. Wood very hard and heavy.

5. **Q. Muhlenbergii** Engelm. YELLOW CHESTNUT OAK. A tree of medium or large size with gray bark. Leaves oblong or oblanceolate, usually acute at the apex and obtuse or rounded at the base, coarsely and evenly toothed; veins straight, impressed above and prominent beneath; petioles slender. Cup hemispherical, sessile or short-peduncled, with flat scales, $\frac{1}{2}$ in. broad, inclosing about half the ovoid acorn, which is $\frac{2}{3}$–$\frac{3}{4}$ in. long. Common on dry soil. Wood close-grained, durable, and valuable.

6. **Q. Prinus** L. SWAMP CHESTNUT OAK. A large tree with brown, ridged bark. Leaves oblong or oblong-lanceolate, rather obtuse, crenately toothed, minutely downy beneath; petioles slender, about 1 in. long. Cup hemispherical, peduncles longer than the petioles, scales acute, tubercular, appressed; acorn oblong, acute, 1 in. or less in length, edible. Common on low ground. Wood strong and valuable.*

7. **Q. virginiana** Mill. LIVE OAK. A large tree with rough gray or brown bark and a low, spreading top. Leaves leathery, evergreen, oblong or oblanceolate, often somewhat 3-lobed on young trees, margin rolled under, dark green and shining above, pale below; petioles short, stout. Fruit often in short racemes, cup top-shaped, scales closely appressed, hoary, peduncles $\frac{1}{2}$–1 in. long; acorn from subglobose to oblong, the longer form occurring on the younger trees. On low ground near the coast. Wood very hard and durable; valued for shipbuilding.*

B. Fruit biennial; leaves entire or with bristle-pointed lobes.

8. **Q. rubra** L. RED OAK. A large tree. Leaves oval or obovate, green above, pale and slightly downy beneath; sinuses shallow and rounded, lobes 8–12, taper-pointed; petioles long. Cups saucer-shaped, with fine scales; acorn ovate or oblong, about 1 in. long. Common; wood not valuable; leaves turning red after frost and often remaining on the tree through the winter.

9. **Q. velutina** Lam. BLACK OAK. A large tree with rough, dark brown outer bark and thick, bright yellow inner bark. Leaves broadly oval, usually cut more than halfway to the midrib, sinuses rounded; lobes about 7, sharply toothed at the apex, smooth above, usually downy on the veins beneath; cup hemispherical or top-shaped, with coarse scales, short-peduncled, inclosing about half the roundish acorn. Common; wood not valuable, but the inner bark used for tanning and dyeing.*

10. **Q. falcata** Michx. SPANISH OAK. A small or medium-sized tree with leaves 3–5-lobed at the apex, obtuse or rounded at the base, grayish-downy beneath, lobes lanceolate and often scythe-shaped,

sparingly cut-toothed. Cup top-shaped, with coarse scales, inclosing about half the nearly round acorn. Common in dry woods. Foliage quite variable in outline and lobing; bark valuable for tanning.*

11. Q. nigra L. Black-Jack Oak. A small tree; leaves obovate, usually with three rounded lobes at the apex, the lobes bristle-pointed, rounded, or slightly cordate at the base, rusty-pubescent beneath, shining above, coriaceous, short-petioled; cup top-shaped, short-peduncled, with coarse and truncate scales, inclosing about one third of the oblong-ovate acorn. An almost worthless tree, its presence indicating a thin and sterile soil.*

12. Q. phellos L. Willow Oak. A tree of medium size, leaves lanceolate or elliptical, scurfy when young and becoming smooth with age, very short-petioled; cup shallow, sessile; acorn subglobose. Wet soil. Often planted for shade.*

19. ULMACEÆ. Elm Family

Trees or shrubs with watery juice; alternate, simple, petiolate, serrate, stipulate leaves, which are usually 2-ranked; and small, bisexual, or somewhat monœcious, apetalous flowers. Calyx of 3–9 sepals, which are distinct or partly united; stamens as many as the sepals and opposite them. Ovary 1–2-celled; styles 2, spreading. Fruit a key, nut, or drupe.*

I. ULMUS L.

Trees with straight-veined, unsymmetrical, doubly serrate leaves; stipules early deciduous. Flowers bisexual; calyx bell-shaped, 4–9-cleft. Stamens slender, protruding. Ovary compressed; styles 2, spreading. Fruit membranaceous, flat, winged on the edge.*

1. U. fulva Michx. Slippery Elm. A tree of medium size, with rough, downy twigs, and rusty, densely woolly bud scales. Leaves large, thick, very rough above, downy beneath, ovate or obovate, taper-pointed at the apex, unsymmetrical, obtuse or somewhat cordate at the base, coarsely and doubly serrate; calyx lobes and pedicels downy. Fruit broadly oval, downy over the seed, the wing smooth. Inner bark very fragrant when dried, and a popular domestic remedy.*

2. U. campestris L. English Elm. A large tree, with short, rather upright or ascending branches. Leaves not bilaterally symmetrical, oval, acute or sometimes a little taper-pointed, doubly serrate, 3–4 in. long. Flowers in close clusters with very short pedicels. Fruit obovate-elliptical, with a fissure extending almost to the seed, nearly smooth and not ciliate. Considerably planted as a shade tree and rarely escaped from cultivation. Very variable, one variety with thick ridges of cork on the twigs.

3. U. americana L. White Elm. A large tree with gray bark, drooping branches, and smooth or slightly downy twigs. Leaves oval or obovate, abruptly taper-pointed at the apex, obtuse and oblique at the base, slightly rough above, soft-downy or soon smooth beneath. Flowers in close fascicles; pedicels slender, smooth. Fruit oval or obovate, with 2 sharp teeth bending toward each other at the apex;

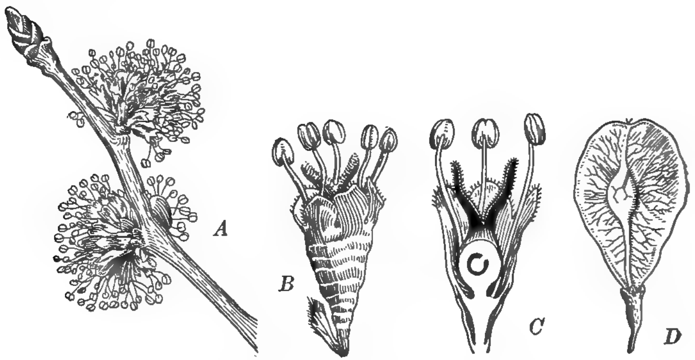


Fig. 12. *Ulmus campestris*

A, a flowering twig; *B*, a flower; *C*, longitudinal section of a flower; *D*, a fruit. (*A*, *D*, natural size; *B*, *C*, enlarged.) (After Wossidlo)

wing reticulate-veined, downy on the margin. In moist, rich soil. A widely planted ornamental tree; wood strong but warping badly, and not durable when exposed.*

4. U. racemosa Thomas. Cork Elm, Rock Elm. A large tree 80–100 ft. high, with the young twigs somewhat downy; the branches often with ridges of cork. Leaves much as in *U. americana*, but smaller and less sharply serrate. Flowers racemed, on thread-like pedicels. Fruit oval, downy on the surface and densely ciliate. In rich soil, especially along river banks. A highly valuable timber tree.

5. U. alata Michx. Winged Elm. A small tree with branches corky-winged. Leaves small, ovate-lanceolate, acute, sharply serrate, base nearly equal-sided, rough above, downy beneath, nearly sessile.

Flowers in small clusters. Fruit oblong, downy on the sides, ciliate on the edges. On rich soil. Occasionally producing a second set of flowers and fruit from September to November.*

II. CELTIS L.

Trees or shrubs with entire or serrate, petioled leaves. Flowers greenish, axillary, on wood of the same season, the staminate in small clusters, the fertile single or 2–3 together.*

1. C. occidentalis L. HACKBERRY. A large or medium-sized tree, having much the appearance of an elm, bark dark and rough. Leaves ovate, taper-pointed at the apex, abruptly obtuse and inequilateral at the base, sharply serrate, often 3-nerved from the base, smooth above, usually somewhat downy below. Fruit a small, dark-purple drupe. On rich soil.

2. C. mississippiensis Bosc. SOUTHERN HACKBERRY. A tree usually smaller than the preceding, bark gray, often very warty. Leaves broadly lanceolate or ovate, long taper-pointed at the apex, obtuse or sometimes heart-shaped at the base, entire or with very few serratures, smooth on both sides, 3-nerved. Fruit a purplish-black, globose drupe.*

20. MORACEÆ. MULBERRY FAMILY

Trees, shrubs, or herbs, usually with milky juice, alternate leaves, large deciduous stipules, and small monœcious or diœcious flowers crowded in spikes, heads, or racemes, or inclosed in a fleshy receptacle. Staminate flowers with a usually 4-lobed calyx, and with as many stamens opposite the lobes; filaments usually inflexed in the bud, straightening at maturity. Pistillate flowers usually 4-sepalous; ovary 1–2-celled, 1–2-ovuled; styles 2; receptacle and perianth often fleshy at maturity.*

I. MORUS L.

Trees or shrubs with milky juice, rounded leaves, and monœcious flowers in axillary spikes. Staminate flowers with a 4-parted perianth, and 4 stamens inflexed in the bud. Pistillate flowers with a 4-parted perianth, which becomes fleshy in the multiple fruit, the pulpy part of which consists of the thickened calyxes of many flowers; ovary sessile; stigmas 2, linear, spreading; the fleshy perianth inclosing the ovary at maturity.*

1. M. rubra L. Red Mulberry. A small tree. Leaves cordate-ovate, often 3–5-lobed on vigorous shoots, taper-pointed at the apex, serrate, rough above, white, densely woolly beneath. Mature fruiting spikes oblong, drooping, dark red or purple, edible. On rich soil. Wood very durable, bearing exposure to the weather.

2. M. alba L. White Mulberry. A small tree. Leaves ovate, heart-shaped, acute at the apex, rounded and often oblique at the base, serrate or sometimes lobed. Smooth and shining on both sides. Mature fruit light red or white. Introduced and common about old dwellings.*

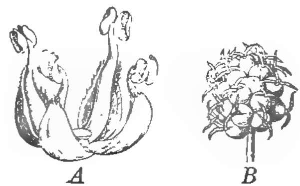


Fig. 13. *Morus alba*

A, staminate flower, about four times natural size; *B*, cluster of pistillate flowers. (After Warming)

II. MACLURA Nutt. (TOXYLON)

A small tree with milky juice. Leaves alternate, petioled, spines axillary. Flowers diœcious. Staminate flowers in short axillary racemes; calyx 4-parted; stamens 4, inflexed in the bud. Pistillate flowers in axillary, peduncled, capitate clusters; calyx 4-parted; ovary sessile; style long; calyxes becoming thickened and fleshy in fruit and aggregated into a large, dense, globular head.*

1. M. pomifera Schneider. Osage Orange. A small tree with ridged, yellowish-brown bark. Leaves minutely downy when young, becoming smooth and shining with age, ovate or ovate-oblong, taper-pointed at the apex, obtuse or subcordate at the base, entire, petioled. Staminate racemes about 1 in. long. Pistillate flower clusters about 1 in. in diameter. Fruit yellowish, tubercled, 3–4 in. in diameter. In rich soil. Native in Texas and extensively planted for hedges. Wood very durable when exposed to the weather, and therefore used for fence posts. As the wood does not swell or shrink with changes in its moisture, it is highly valued for wheel hubs, etc.*

III. BROUSSONETIA L'Her.

Small trees with milky juice. Leaves alternate, petioled. Flowers diœcious; staminate in cylindrical spikes, with a

4-cleft calyx, 4 stamens, and a rudimentary ovary; pistillate flowers in capitate clusters, calyx 3–4-toothed. Ovary stalked; style 2-cleft. Fruit in a globular head.*

1. **B. papyrifera** Vent. PAPER MULBERRY. A round-topped tree with yellowish-brown bark. Leaves cordate, often irregularly 2–3-lobed, serrate, rough above, downy beneath, long-petioled. Staminate spikelets peduncled, 2–3 in. long. Pistillate heads stout, peduncled, about 1 in. in diameter. Introduced from Asia and very common S. about old dooryards.*

IV. CANNABIS L.

Coarse herbs with very tough, fibrous bark. Leaves usually opposite, palmately compound. Flowers small, diœcious, greenish, the staminate ones in compound racemes or panicles, the pistillate ones in spikes. Calyx of the staminate flowers of 5 sepals, that of the pistillate flowers of 1 large sepal which covers the ovary and the akene.

1. **C. sativa** L. COMMON HEMP. An erect plant, 4–8 ft. high. Leaves large, petioled, of 5–7 lanceolate, irregularly serrate or toothed leaflets. Cultivated from Europe, S. and W., for its fiber, and sometimes runs wild along roadsides in rich soil.

21. URTICACEÆ. NETTLE FAMILY

Herbs with watery juice, stem and leaves often clothed with stinging hairs. Leaves undivided, stipulate. Flowers small, greenish, unisexual, apetalous in axillary clusters. Calyx of the staminate flowers 4–5-parted or 4–5-sepalous; stamens as many as the sepals and opposite them; filaments inflexed in the bud and straightening at maturity; anthers 2-celled. Calyx of pistillate flowers 2–4-sepalous; ovary sessile, 1-celled; stigma simple or tufted. Fruit an akene commonly inclosed in the dry, persistent calyx.*

URTICA L.

Annual or perennial herbs. Leaves with stinging hairs, opposite, petioled, several-nerved, dentate or incised, stipulate. Flowers monœcious or diœcious. Calyx of the staminate flowers 4-parted; stamens 4, inserted around a rudimentary ovary. Pistillate flowers with 4 unequal sepals, the inner ones dilated in fruit; akenes smooth, compressed.*

1. U. gracilis Ait. SLENDER NETTLE. Perennial, slender, with some stinging hairs, 2–6 ft. high. Leaves ovate-lanceolate or narrower, with slender petioles, taper-pointed, sharply serrate, with 3-5-nerves arising from the rounded or sometimes almost heart-shaped base, almost smooth; stipules lanceolate. Flower clusters in branching panicled spikes, longer than the petioles. Flowers diœcious or bisexual.

2. U. urens L. SMALL NETTLE. Annual; stem stout, 4-angled, hairy, 12–18 in. tall, with few stinging hairs; branches slender. Leaves elliptical or ovate, serrate or incised, 3–5-nerved, acute or obtuse at the ends, thin, hairy; petioles often as long as the blades; stipules short. Flower clusters axillary, in pairs, loose, mostly shorter than the petioles. On damp soil in waste places. Naturalized from Europe.

22. SANTALACEÆ. SANDALWOOD FAMILY

Herbs, shrubs, or trees with entire leaves. Flowers usually small. Calyx 4–5-cleft, its limb epigynous. Corolla wanting. Stamens as many as the calyx lobes and opposite them, inserted on the margin of a fleshy disk. Style 1; ovary 1-celled, with 2–4 ovules borne at the top of a free central placenta. Fruit 1-seeded.

COMANDRA Nutt.

Low, smooth perennials with herbaceous stems, rather woody below, often parasitic. Leaves alternate and nearly sessile. Flowers nearly white, in small umbel-like clusters, bisexual. Calyx bell-shaped at first. Stamens borne on a 5-lobed disk which surrounds the pistil; anthers connected by a tuft of hairs to the calyx lobes.

1. C. umbellata Nutt. BASTARD TOADFLAX. Plant 8–10 in. high, with very leafy stems. Roots attached to the roots of trees, from which they draw nourishment. Leaves oblong or oblanceolate, pale, nearly 1 in. long. Umbel-like clusters about 3-flowered, longer than the leaves. Rocky, dry woods.

23. LORANTHACEÆ. Mistletoe Family

Parasitic shrubs or herbs, leaves opposite, leathery, without stipules. Flowers monœcious or diœcious, clustered or solitary; perianth of both calyx and corolla, or of a calyx only, or sometimes wanting, the limb epigynous; sepals 2–8. Stamens as many as the sepals, and opposite them. Ovary 1-celled; ovule 1. Fruit a berry.*

PHORADENDRON Nutt.

Evergreen, shrubby plants, parasitic on trees; branches greenish, jointed, and very brittle. Leaves leathery. Flowers diœcious, in short jointed spikes. Staminate flowers globular, calyx 2–4-lobed, stamens sessile at the base of the lobes, anthers transversely 2-celled. Stigma sessile. Berry 1-seeded.*

1. **P. flavescens** Nutt. American Mistletoe. Very round, bushy; branches very brittle at the joints, opposite or whorled, 6 in. to 2 ft. long. Leaves flat, leathery, or somewhat fleshy, nearly veinless, obovate, entire, with short petioles. Flowering spikes solitary or 2–3 together in the axils of the leaves. Berry roundish, white, glutinous. Parasitic on many deciduous trees.*

24. ARISTOLOCHIACEÆ. Dutchman's Pipe Family

Herbaceous plants, apparently stemless or with twining and leafy stems. Leaves alternate, without stipules, petioled, mostly roundish or kidney-shaped. Flowers axillary, solitary or clustered, bisexual. Calyx tubular, 3- or 6-lobed, usually colored. Petals none. Stamens 6–12, epigynous. Pistil 1; ovary mostly 6-celled, many-seeded.*

I. ASARUM L.

Perennial, apparently stemless, aromatic herbs, with slender, branching rootstocks. Leaves long-petioled, from kidney-shaped to halberd-shaped. Flowers axillary, peduncled. Calyx actinomorphic, 3-lobed, withering-persistent. Stamens 12, the filaments partially united with the style and usually prolonged beyond the anthers. Ovary 6-celled, with parietal placentæ, many-seeded. Mature capsule roundish, often somewhat fleshy.*

1. A. canadense L. WILD GINGER. Plant soft-hairy. Leaves 2, large, kidney-shaped, on long petioles, with the flower borne on a short peduncle between them. Flower greenish outside, brownish-purple inside. Calyx lobes epigynous, taper-pointed, widely spreading, relaxed at the tip. Rich, shady woods, common N.

2. A. virginicum L. VIRGINIA ASARUM. Leaves evergreen, 1–3 to each plant, smooth, mottled, round-cordate, entire, 2–3 in. long and broad; petioles smooth or downy along one side, 3–7 in. long. Flowers nearly sessile, greenish without, dull purple within, $\frac{2}{3}$–$\frac{3}{4}$ in. long; tube inflated below, narrow at the throat, lobes spreading. Rich, shady woods.*

II. ARISTOLOCHIA L.

Erect or twining perennial herbs or woody vines. Leaves alternate, heart-shaped at the base, palmately nerved, petioled, entire. Flowers zygomorphic, solitary, or in small clusters. Calyx perigynous or epigynous, tubular, irregular. Stamens mostly 6, sessile, apparently united to the angled and fleshy 3–6-lobed or -angled stigma. Capsule naked, 6-valved; seeds very numerous.*

1. A. macrophylla Lam. DUTCHMAN'S PIPE, PIPE VINE. A tall climber. Leaves dark green, smooth, round-kidney-shaped, sometimes 1 ft. wide. Peduncles 1-flowered, with a single clasping bract. Calyx 1½ in. long, bent into the shape of a pipe, its border abruptly spreading, brownish-purple. Rich woods, often cultivated.

2. A. tomentosa Sims. DUTCHMAN'S PIPE. Stem woody, climbing high, branches and leaves densely woolly. Leaves heart-shaped, prominently veined, 3–5 in. long and broad. Flowers axillary, mostly solitary, on slender peduncles. Calyx bent in the shape of a pipe, yellowish-green with a dark purple throat, limb unequally 3-lobed, rugose, reflexed. Anthers in pairs below the 3 spreading lobes of the stigma. Capsule oblong. Stems sometimes 30 ft. long. Rich woods S.*

25. POLYGONACEÆ. BUCKWHEAT FAMILY

Herbs with alternate, entire leaves, and usually with sheathing stipules above the swollen joints of the stem. Flowers apetalous, generally bisexual, with a 3–6-cleft calyx, generally colored and persistent. Fruit a compressed or 3-angled akene, inclosed in the calyx; seeds with endosperm, which does not generally inclose the embryo. Stamens 4–12, on the base of the calyx.

I. RUMEX L.

Coarse herbs, many of them troublesome weeds. Flowers small, usually green or greenish, generally in whorls borne in panicled racemes. Calyx of 6 nearly distinct sepals, the 3 inner ones larger and more petal-like than the 3 outer, and one or more of them usually with a little knob or tubercle on its back. Stamens 6; styles 3; stigmas short, fringed. Fruit a 3-angled akene, closely covered by the 3 inner calyx lobes, enlarged and known as valves.

1. **R. crispus** L. YELLOW DOCK. Stout, smooth, 3–4 ft. high. Leaves lanceolate, margins very wavy, acute, the lower more or less heart-shaped. Root long, tapering gradually downward, yellow, very tough. Flowers in whorls crowded in long, straight, slender racemes. Valves roundish-heart-shaped, mostly tubercled. A very hardy weed, naturalized from Europe.

2. **R. verticillatus** L. SWAMP DOCK. Perennial. Stem stout, smooth, erect or ascending, 3–5 ft. tall. Lower leaves oblong, obtuse at the apex and usually heart-shaped at the base, long-petioled, often 12–18 in. long; upper leaves narrower and often acute at both ends. Flowers bisexual or somewhat monœcious, in dense whorls; pedicels slender, $\frac{1}{2}$–$\frac{2}{3}$ in. long, tapering downward, reflexed at maturity. Calyx green, the valves broadly triangular, abruptly pointed, reticulated, a distinct long and narrow tubercle on the back of each. Swamps and wet ground.*

3. **R. Acetosella** L. SHEEP SORREL. Perennial herbs with slender creeping and bud-bearing roots. Stem simple or branched, smooth. Leaves petioled, narrowly halberd-shaped, usually widest above the middle, the apex acute or obtuse; upper stem leaves often nearly linear and not lobed. Flowers diœcious, small, in terminal, naked, panicled, interrupted racemes. Calyx greenish; the pistillate panicles becoming reddish. Fruit less than $\frac{1}{12}$ in. long, granular, longer than the calyx. A common weed, naturalized from Europe, in dry fields and on sour soils. Foliage very acid.*

II. POLYGONUM L.

Annual or perennial, terrestrial or aquatic herbs, with enlarged joints and simple, alternate, entire leaves; the sheathing stipules often cut or fringed. Flowers bisexual, usually white or rose-colored, each flower or cluster subtended by a membranaceous bract similar to the stipules of the leaves.

Calyx mostly 5-parted, the divisions petal-like, erect and persistent. Stamens 3–9; styles 2–3-parted. Fruit lens-shaped or 3-angled.*

1. **P. aviculare** L. Knotgrass. Annual or perennial. Stem prostrate or ascending, diffuse, smooth, 6–24 in. long. Leaves small, lanceolate or linear-oblong, obtuse, nearly or quite sessile. Sheaths thin and dry, 2–3-cleft or cut. Flower clusters axillary, 1–5-flowered; flowers inconspicuous, nearly sessile. Calyx greenish-white, 5-parted, the lobes with white or colored borders. Stamens 5–8; style 3-parted. Akene 3-angled, not shining. A common weed in dooryards and where the ground is trampled.*

2. **P. lapathifolium** L. Annual. Stem branching, 1–4 ft. high. Leaves lanceolate or broader, wedge-shaped at the base and tapering from near the base to an extremely slender point, ciliate, varying greatly in length. Sheaths not ciliate or fringed. Spikes oblong to linear, closely flowered, erect or nearly so, $\frac{1}{2}$–2 in. long. Calyx white or pink. Stamens 6; style 2-cleft. Akene ovate, lens-shaped, $\frac{1}{12}$ in. wide or less. In wet soil.

3. **P. acre** HBK. Water Smartweed. Perennial. Smooth or nearly so; stems erect or ascending, rooting below, 2–5 ft. high. Leaves lanceolate or broader, tapering at both ends, petioled, ciliate, translucent-dotted, acrid, $1\frac{1}{2}$–8 in. long. Sheaths cylindrical, falling early, bristly-fringed. Spikes erect or nearly so, loosely flowered, $\frac{3}{4}$–3 in. long. Calyx whitish-greenish or flesh color. Stamens 8; style usually 3-parted. Akene oblong, lens-shaped, smooth and shining. Swamps and wet soil, especially S.

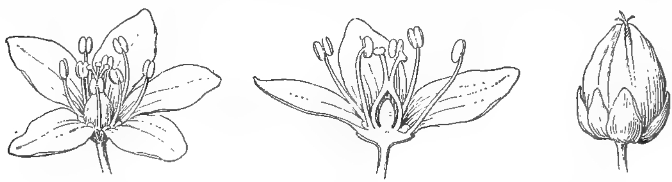
4. **P. Persicaria** L. Lady's Thumb. Annual. Smooth or nearly so. Stem erect or ascending, 6–24 in. high. Leaves lanceolate or narrower, tapering at both ends, usually with a dark triangular or crescent-shaped spot near the center, very variable in length. Sheaths more or less bristle-fringed. Spikes ovoid or oblong, dense, erect, peduncled, $\frac{3}{8}$–2 in. long. Calyx pink or purple. Stamens usually 6; styles 2–3-cleft more than half their length. Akene broadly ovate and lens-shaped, often somewhat triangular, smooth and shining. In waste ground, often a troublesome weed. Naturalized from Europe.

5. **P. hydropiperoides** Michx. Mild Water Pepper. Perennial. Stem smooth, slender, erect, decumbent, or prostrate, 1–3 ft. long. Leaves usually narrowly lanceolate, but variable, acute, ciliate, 2–6 in. long. Sheaths wrinkled, bristle-fringed. Spikes erect, slender, often with the flowers scattered, $\frac{1}{2}$–$2\frac{1}{2}$ in. long. Calyx pale pink, greenish or nearly white. Stamens 8; style 3-parted more than half its length. Akene 3-angled, smooth and shining. In swamps and wet places, especially S.

6. **P. dumetorum** L. False Buckwheat. Perennial. Stems slender, twining, branched, 2–10 ft. long. Leaves ovate, taper-pointed, heart-shaped to halberd-shaped at the base, long-petioled. Stipules cylindrical, truncate. Flowers in axillary, more or less compound and leafy racemes. Calyx greenish-white, the outer lobes winged and forming a margin on the pedicel. Stamens 8. Stigmas 3. Akene 3-angled, black, smooth, and shining. Margins of fields and thickets.*

III. FAGOPYRUM Hill

Smooth annual herbs, with more or less triangular leaves; the sheathing stipules cylindrical or funnel-shaped. Flowers bisexual, white, greenish or tinged with rose color, in terminal or axillary, often panicled, racemes. Calyx petal-like (Fig. 14), 5-parted. Stamens 8. Styles 3, with knobbed stigmas. Akene 3-angled, much longer than the persistent calyx (Fig. 14).



A *B* *C*

Fig. 14. Buckwheat (*Fagopyrum esculentum*)

A, flower; *B*, section of flower; *C*, fruit. (All somewhat magnified.) (After Marchand)

1. **F. esculentum** Mœnch. Buckwheat. Annual, nearly smooth. Leaves halberd-shaped, 1–3 in. long. Flowers white or nearly so, with 8 yellow nectar-bearing glands between the stamens. Old fields and thickets, escaped from cultivation. Introduced from Europe or western Asia.

26. CHENOPODIACEÆ. Goosefoot Family

Herbs or shrubs. Leaves simple, alternate, without stipules. Flowers small, actinomorphic, either bisexual or more or less monœcious or diœcious. Calyx free from the ovary. Corolla wanting. Stamens usually 5, opposite the sepals. Styles or stigmas generally 2. Fruit with 1 seed, usually inclosed in a small, bladdery sac, sometimes an akene.

I. SPINACIA L.

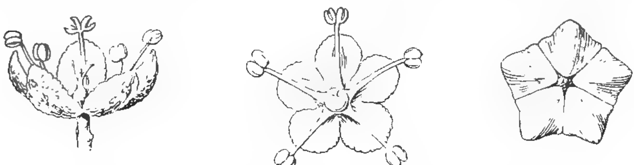
Herbs. Flowers diœcious, in close axillary clusters. Staminate flowers 3–5-sepaled, with 4 or 5 projecting stamens; pistillate flowers with a tubular 2-toothed or 4-toothed calyx.

1. S. oleracea Mill. SPINACH. A soft annual or biennial herb. Leaves triangular, ovate, or halberd-shaped, petioled. Cultivated from Asia as a pot herb.

II. CHENOPODIUM L.

Annual or perennial herbs. Stems erect or spreading. Leaves alternate, usually white-mealy. Flowers small, greenish, in panicled spikes. Calyx 3–5-parted, the lobes often slightly fleshy and keeled. Stamens 5; filaments thread-shaped. Styles 2–3, distinct or united at the base. Seed lens-shaped.*

1. C. Botrys L. JERUSALEM OAK. A low, spreading plant, covered with sticky down. Leaves with slender petioles, oblong, sinuately



A *B* *C*

FIG. 15. Pigweed (*Chenopodium album*)

A, *B*, flower; *C*, fruit. (All about seven times natural size)

lobed or the lobes pinnate. Flowers in loose, diverging, leafless racemes. The whole plant is sweet-scented. Introduced from Europe and naturalized in gardens and along roadsides.

2. C. glaucum L. OAK-LEAVED GOOSEFOOT. Annual, succulent, somewhat mealy. Stem spreading, much branched, 5–12 in. high. Leaves varying from oblong to lanceolate, obtuse, some or all of them more or less sinuate-toothed, 1–2 in. long. Flower clusters mostly small axillary spikes. A common weed. Naturalized from Europe.

3. C. album L. LAMB'S QUARTERS. COMMON PIGWEED. Annual, somewhat mealy. Stem erect, usually branching, 1–4 ft. high. Leaves varying from rhombic-ovate to (the uppermost) nearly linear, narrowed at the base, acute, somewhat angulate-toothed, 1–4 in. long. Spikes terminal and in the leaf axils, often panicled. Calyx with keeled lobes, in fruit nearly covering the smooth seed. A common and troublesome weed. Naturalized from Europe.

4. **C. urbicum** L. UPRIGHT GOOSEFOOT. Annual, little or not at all mealy. Stem stout, erect, and with erect branches, 1–3 ft. high. Leaves halberd-shaped or triangular, acute, coarsely and sharply toothed, except the upper ones, the larger ones 3–6 in. long. Spikes in a narrow, erect panicle. Lobes of the calyx not keeled. Waste ground. Naturalized from Europe.

27. AMARANTHACEÆ. AMARANTH FAMILY

Mostly herbs, with nearly the characters of the *Chenopodiaceæ,* but with usually 3 dry, translucent, persistent, often colored, bracts beneath the flower. Most of the genera are tropical; our commonest species are troublesome weeds, usually flowering in midsummer or later.

AMARANTHUS L.

Mostly annual herbs. Leaves alternate, simple, thin, usually entire, often bristle-tipped. Flowers mostly 3-bracted, small, green or purplish in our wild species, in axillary clusters or dense terminal spikes. Calyx of 5 or sometimes 3 distinct erect sepals. Stamens distinct, usually 5, anthers 2-celled. Styles or stigmas 2 or 3. Fruit small, bladdery, 1-seeded, with 2 or 3 beaks formed by the withered styles.

1. **A. graecizans** L. TUMBLEWEED. Smooth, pale green. Stem diffusely branched, whitish, the branches slender, ascending. Leaves small, varying from obovate to spatulate, obtuse or retuse, $\frac{3}{8}$–$1\frac{1}{2}$ in. long. Flowers greenish, in small axillary clusters, covered by stiff, sharp-pointed bracts. Sepals 3. In waste ground and a common field and garden weed. In the autumn the leaves drop and the globular stem and branches roll freely about before the wind.

2. **A. spinosus** L. SPINY AMARANTH. Stem stout, ridged, smooth, bushy-branched, often red, 1–4 ft. high. Leaves varying from ovate to lanceolate, tapering to both ends, dull green, $\frac{3}{4}$–3 in. long, each with a pair of stiff spines in its axil. Flower clusters of two sorts,

the upper ones of staminate flowers in long slender spikes, the axillary ones globular, composed of pistillate flowers. Bracts lance-awl-

A B C

FIG. 16. Prince's feather (*Amaranthus hypochondriacus*)

A, staminate flower; *B*, pistillate flower; *C*, fruit. (All magnified.) (After Schnizlein)

shaped about the length of the 5 sepals. In waste ground, fields, and gardens. Naturalized from tropical America.

A. retroflexus L. and **A. hybridus** L., usually known as pigweed, are common autumn-flowering weeds.

28. PHYTOLACCACEÆ. POKEWEED FAMILY

Plants with alternate entire leaves. Flowers bisexual, 5-parted, with the characters of the Goosefoot Family, but the ovary generally consisting of several carpels, which unite to form a berry.

PHYTOLACCA L.

Perennial herbs. Stems tall, branching. Leaves large, entire. Flowers small, in terminal racemes, pedicels bracted. Calyx of 4–5 nearly equal, persistent sepals. Stamens 5–15, inserted at the base of the calyx. Styles 5–12, recurved at the apex. Fruit a depressed-globose, juicy berry.*

1. **P. decandra** L. POKEWEED. Stems erect, smooth, branched above, usually dark purple, 4–7 ft. tall; root large, fleshy, poisonous. Leaves ovate-lanceolate, smooth, acute, long-petioled. Racemes peduncled, many-flowered, opposite the leaves; flowers white, becoming purplish. Stamens 10, shorter than the sepals. Styles 10, carpels 10.

Fruit a dark purple berry. A weed on waste ground. The young branches are often eaten like asparagus, and the root, known as "garget root," is used in medicine.*

29. AIZOACEÆ. Ice Plant Family

Mostly fleshy plants, mainly natives of Africa. Flowers often large and showy. Stamens often doubled and some of them petal-like. Ovary 2–many-celled.

[Our only very common genus belongs to a subfamily which has little resemblance to the fleshy "ice plants," found in some gardens, which best represent the family as a whole.]

MOLLUGO L.

Low branching annuals. Sepals 5, greenish outside, white inside. Corolla wanting. Stamens 5, alternate with the sepals, or 3, alternate with the cells of the ovary. Capsule 3-celled, many-seeded.

1. **M. verticillata** L. Carpet Weed. Stems branching and forming radiating patches. Leaves clustered in apparent whorls at the joints of the stem, spatulate. Flowers in little sessile umbels at the joints. Stamens commonly 3. A troublesome weed in sandy soil and common on sandy beaches and river banks.

30. PORTULACACEÆ. Purslane Family

Generally herbs. Leaves opposite or alternate, entire; stipules dry and membranaceous. Sepals 2. Petals 4 or more, distinct or united below. Stamens 4 or more, hypogynous or perigynous. Ovary usually superior, 1-celled; style simple or 3-cleft; ovules 2–many. Capsule opening transversely with a lid, or 2–3-valved.

I. CLAYTONIA L.

Perennial. Stem simple, smooth, erect, 4–10 in. high. Leaves 2, opposite, smooth, succulent. Flowers in a terminal raceme. Sepals 2, ovate, persistent. Petals 5, sometimes joined at the base. Stamens 5, somewhat perigynous. Style 3-cleft; ovary 1-celled, 3–6-seeded.

1. C. virginica L. SPRING BEAUTY. Stem simple, erect from a deep, tuberous root. The 2 stem leaves narrowly elliptical, 3–6 in. long, smooth, fleshy; basal leaves occasionally produced. Flowers on short pedicels. Petals white or pink, with darker veins, $\frac{1}{4}$–$\frac{3}{8}$ in. long, notched. Capsules shorter than the persistent sepals. Common in rich woods.*

2. C. caroliniana Michx. NORTHERN SPRING BEAUTY. Flowers fewer, smaller, and whiter than in No. 1, fragrant. Leaves 1–2 in. long, ovate-lanceolate or spatulate, rather distinctly petioled. Moist woods, especially N.

II. PORTULACA L.

Annual. Stems low, diffuse, and spreading, fleshy. Leaves entire, mostly alternate. Flowers terminal, perigynous. Sepals 2, united at the base. Petals usually 5, quickly withering. Stamens 8–20. Style 3–8-parted. Capsules globose, opening by the upper portion coming off like a lid, 1-celled, many-seeded.*

1. P. oleracea L. PURSLANE. Stems prostrate, diffuse, fleshy. Leaves alternate, flat, obovate or wedge-shaped. Flowers solitary, sessile, opening in bright sunshine in the morning and usually withering before noon. Sepals broad, acute. Petals yellow. Stamens 10–12. Capsule very many-seeded, seeds small, wrinkled. A common garden weed.*

2. P. grandiflora Hook. GARDEN PORTULACA. Stems fleshy, erect or ascending, densely hairy or nearly smooth, 3–6 in. long. Leaves alternate, cylindrical, fleshy, $\frac{1}{2}$–1 in. long. Flowers 1–2 in. wide, white, yellow, or red, showy, opening only in sunlight. Common in cultivation and often growing spontaneously.*

31. CARYOPHYLLACEÆ. PINK FAMILY

Herbs sometimes woody below, with thickened nodes. Leaves opposite, entire; stipules small and dry or none. Sepals 4–5. Petals 4–5 (rarely 0), usually hypogynous. Stamens usually 8–10, hypogynous or perigynous. Styles 2–5 (rarely 1). Ovules 1–many. Fruit usually a capsule.

A

Sepals distinct or nearly so. Petals (if any) without claws. Capsules several–many-seeded.

Styles usually 3. Capsule ovoid. Stellaria, I

Styles 5 or 4. Capsule cylindrical. Cerastium, II

B

Sepals more or less united. Petals with claws. Capsule several–many-seeded.

(*a*) Calyx without bracts, its lobes long and leaf-like. Agrostemma, III

(*b*) Calyx without bracts, lobes not leaf-like. Styles 3 or 4. Silene, V

(*c*) Calyx without bracts, lobes not leaf-like. Styles 5 (rarely 4). Lychnis, IV

(*d*) Calyx with little bracts at the base. Styles 2. Dianthus, VI

I. STELLARIA L. (ALSINE)

Slender, usually smooth herbs. Flowers small, white, solitary, or in forking cymes. Sepals 5 (rarely 4). Petals 5 (rarely 4), 2-cleft or -divided. Stamens 10 (rarely 8, 5, or 3), maturing in 2 sets. Styles 3 (rarely 4 or 5), opposite the same number of petals; ovary 1-celled, many-ovuled. Capsule short, splitting into as many valves as there are styles.

1. S. longifolia Muhl. Long-Leaved Stitchwort. Stem slender, usually erect, 8–18 in. high, often sharply 4-angled. Leaves linear or nearly so, spreading. Flower clusters peduncled, many-flowered, the pedicels spreading. Petals 2-parted, at length longer than the calyx. Perennial in meadows and grassy thickets, especially N.

2. S. graminea L. Smooth, weak, ascending. Stem sharply 4-angled, 12–20 in. long. Leaves linear-lanceolate or broader, widest a little above the base, ciliate, acute, $\frac{3}{4}$–$1\frac{1}{4}$ in. long. Cyme loose, with slender, widely spreading pedicels. Flowers $\frac{1}{4}$–$\frac{3}{4}$ in. in diameter. Sepals and petals about equal in length, the petals cleft almost to the base. Seeds with many minute tubercles. Fields and roadsides, often among grass. Naturalized from Europe.

3. S. media Cyrill. Common Chickweed. Stem prostrate, 6–18 in. long, with a line or two of hairs along it. Leaves ovate, taper-pointed, the lower petioled, the upper sessile. Petals shorter than the sepals, sometimes wanting. An annual weed, naturalized from Europe, common in damp, shady places N.

II. CERASTIUM L.

Annual or perennial. Stems diffuse, usually downy; leaves opposite. Flowers white, peduncled, in terminal, regularly forking cymes. Sepals 4–5. Petals 4–5, notched or 2-cleft. Stamens 10. Styles 5 or less. Capsules cylindrical, 1-celled, many-seeded.*

1. **C. arvense** L. FIELD CHICKWEED. Perennial. Stems tufted, erect or ascending, 4–10 in. high. Basal leaves and those of flowerless branches linear-oblong, crowded; those of flowering stems linear or lance-linear. Flowers $\frac{1}{2}$–$\frac{2}{3}$ in. in diameter, in cymes. Petals obcordate, much longer than the sepals. Pods hardly longer than the calyx. In dry or rocky soil.

2. **C. vulgatum** L. MOUSE-EAR CHICKWEED. Annual or sometimes perennial. Stems diffuse, tufted, clammy-downy, 6–12 in. high. Lower leaves spatulate, the upper oblong, acute, or obtuse; bracts thin and dry. Flowers in loose cymes, pedicels becoming much longer than the calyx. Sepals lanceolate, acute, about as long as the 2-cleft petals. Slender capsule becoming twice as long as the calyx and curved upward. A common garden weed.*

3. **C. brachypodum** Robinson. Annual. Stems 3–10 in. high, clammy-downy. Lower leaves oblanceolate or spatulate, the upper ones linear to lanceolate. Pedicels shorter or not much longer than the calyx. Petals longer than the sepals. Capsule straight or slightly curved upwards. In dry soil.

III. AGROSTEMMA L.

Annual. Stem pubescent, branching above. Leaves linear-lanceolate or linear, pubescent, sessile. Flowers showy, on long and naked peduncles in terminal corymbs. Calyx tubular, the tube oblong, 10-ribbed; lobes elongated, leaf-like, deciduous. Petals 5, shorter than the calyx lobes, entire. Stamens 10. Styles 5, capsules 1-celled.*

1. **A. Githago** L. CORN COCKLE. Stem erect, rather slender, 1–3 ft. tall, gray, with long, appressed hairs. Leaves linear-lanceolate, acuminate, erect, 2-4 in. long. Petals obovate, notched, purple. Capsule 5-toothed, many-seeded; seeds black. An introduced weed, common in grain fields.*

IV. LYCHNIS L.

Plants with nearly the same characteristics as *Silene*, but usually with 5 styles.

1. **L. Coronaria** Desr. MULLEIN PINK. A forking perennial plant, 2 ft. high, covered with white, cottony down. Leaves very wavy,

spatulate; stem leaves ovate-lanceolate, wavy, clasping. Peduncles long, 1-flowered. Flowers about $1\frac{1}{4}$ in. broad, deep crimson. Calyx tube very strongly 5-ribbed, with 5 smaller ones between; calyx teeth short and slender. Petals somewhat notched. Cultivated in old gardens; from Europe.

2. L. chalcedonica L. SCARLET LYCHNIS, LONDON PRIDE. A tall, hairy perennial (about 2 ft.). Leaves lance-ovate, somewhat clasping. Flower cluster flat-topped and very dense. Flowers bright scarlet, not very large. Petals 2-lobed. Common in old gardens; from Japan.

3. L. Drummondii Wats. Perennial, erect, glandular-downy and sticky, 1–3 ft. high. Leaves oblanceolate or linear, acute, $\frac{3}{4}$–3 in. long. Flowers few, on slender pedicels, white or purplish, $\frac{3}{8}$–$\frac{3}{4}$ in. long. Petals not much longer than the tubular calyx. Capsule $\frac{1}{2}$–$\frac{2}{3}$ in. long. Seeds with little tubercles. In dry soil W.

V. SILENE L.

Annual or perennial herbs. Stems erect or decumbent and diffuse. Leaves often connate or whorled. Flowers clustered or solitary, usually pink or white. Calyx tubular, more or less inflated, 5-toothed, 10-nerved, bractless. Petals 5, long-clawed, and with the ten stamens inserted at the base of the ovary. Styles 3; ovary 1-celled or 3-celled at the base, opening by 6 teeth, many-seeded. Seeds usually roughened.*

1. S. antirrhina L. SLEEPY CATCHFLY. Stem smooth, slender, 8–30 in. high, sticky in spots. Leaves lanceolate or linear. Flowers rather few and small, panicled. Calyx ovoid. Petals inversely heart-shaped, pink, opening only for a short time in sunshine. Dry waste ground.

2. S. Armeria L. CATCHFLY, NONE-SO-PRETTY. A smooth, erect annual or biennial, 6–15 in. high. Several nodes of the stem are usually covered for part of their length with a sticky substance. Leaves very smooth, with a bloom beneath, lanceolate or oblong-lanceolate, clasping. Flowers showy, dark pink, nearly $\frac{1}{2}$ in. in diameter, in flat-topped clusters. Calyx club-shaped. Petals somewhat notched. Cultivated from Europe and introduced.

3. S. noctiflora L. NIGHT-FLOWERING CATCHFLY. A tall, coarse annual or biennial weed, covered with sticky hairs. Lower leaves spatulate, upper ones lanceolate, pointed. Flowers large, white, opening at night or in cloudy weather. Calyx teeth long, awl-shaped. Petals 2-parted. In fields and gardens. Naturalized from Europe.

4. S. pennsylvanica Michx. WILD PINK. A perennial with low, clustered stems (4–8 in.). Basal leaves wedge-shaped or spatulate, those of the stem lanceolate. Flowers medium-sized, clustered. Petals wedge-shaped, notched, pink, with a crown at the throat of the corolla. Gravelly soil E.

5. S. virginica L. FIRE PINK. A slender perennial, with erect stem, 1–2 ft. high. Basal leaves spatulate, the upper leaves oblong-lanceolate. Flowers few, peduncled, large and showy, bright crimson. Corolla crowned, petals deeply 2-cleft. Woods.

6. S. latifolia Britten and Rendle. SNAPPERS, RATTLEBOX. A perennial branched herb about 1 ft. high. Leaves opposite, smooth, ovate or ovate-lanceolate. Calyx thin and bladdery, beautifully veined. Petals white, 2-cleft. Capsule nearly globular. In fields and along roadsides, especially eastward. Naturalized from Europe.

VI. DIANTHUS L.

Tufted, mostly perennial herbs, often shrubby at the base. Leaves narrow and grass-like. Flowers solitary or variously clustered. Calyx tubular, 5-toothed, with overlapping bracts at the base. Petals 5, with long claws. Stamens 10, maturing 5 at a time. Styles 2; ovary 1-celled. Capsule cylindrical, 4-valved at the top.

1. D. barbatus L. SWEET WILLIAM. Perennial, often in large clumps. Stems erect, branching above, smooth, 1–2 ft. tall. Leaves lanceolate, 2–3 in. long, acute. Flowers crimson-pink, white or variegated, in terminal clusters; bracts linear, as long as the calyx. Common about old gardens; from Europe.*

2. D. Armeria L. DEPTFORD PINK. Rather erect, annual, with stiff stems 1–2 ft. high. Leaves very dark green, linear, 1–2 in. long, the lower obtuse, the upper acute. Flowers loosely clustered, small, dark pink. Calyx tube $\frac{1}{2}$–$\frac{3}{4}$ in. long, nearly cylindrical. Petals narrow, speckled with very small whitish dots. In sandy fields eastward. Introduced from Europe; sometimes cultivated.

3. D. plumarius L. COMMON PINK, GRASS PINK. Leaves grass-like, with a whitish bloom. Petals white, pink, or variegated, with the limb fringed. Flowers solitary, fragrant. Hardy perennials, cultivated from Europe.

4. D. Caryophyllus L. CARNATION, CLOVE PINK. Much like the preceding species, but with larger fragrant flowers; the broad petals merely crenate. Hothouse perennials (some hardy varieties), cultivated from Europe.

32. NYMPHÆACEÆ. Water Lily Family

Perennial aquatic herbs. Leaves usually floating, often shield-shaped. Flowers borne on naked scapes. Floral envelopes and stamens all hypogynous or epigynous. Sepals 3–6. Petals 3–5 or often very numerous. Stamens many. Carpels 3 or more, free or united. Fruit a berry or a group of separate carpels.

I. NYMPHÆA L.

Rootstock horizontal, thick, cylindrical. Leaves heart-shaped, floating or erect. Flowers yellow. Sepals 4–6, green on the outside, obovate, concave. Petals many, hypogynous, the inner ones becoming small and stamen-like. Stamens many, hypogynous. Ovary cylindrical, many-celled; stigma disk-shaped. Fruit ovoid.*

1. N. advena Ait. Yellow Pond Lily, Cow Lily, Spatter-Dock. Leaves oval or orbicular, rather thick, often downy beneath. Flowers bright yellow, 2–3 in. in diameter, depressed-globular. Sepals 6. Petals thick and fleshy, truncate. Stamens in several rows; anthers nearly as long as the filaments. In slow streams and still water.*

II. CASTALIA Salisb.

Rootstock horizontal, creeping extensively. Leaves floating, entire, shield-shaped or heart-shaped. Flowers showy. Sepals 4, green without, white within. Petals many, white, becoming smaller towards the center. Stamens many, the outer with broad and the inner with linear filaments. Ovary many-celled, stigmas shield-shaped and radiating. Fruit berry-like, many-seeded.*

1. C. odorata Woodville and Wood. White Water Lily. Rootstock large, branched but little. Leaves floating, entire, the notch narrow and basal lobes acute, green and smooth above, purple and downy beneath. Petioles and peduncles slender. Flowers white, very fragrant, opening in the morning, 3–5 in. broad. Fruit globose; seeds inclosed in a membranaceous sac. In ponds and still water.*

2. C. tuberosa Greene. Much like No. 1. Rootstock bearing loosely attached, often compound tubers. Leaves round-kidney-shaped, seldom purple beneath. Flowers larger than in No. 1, scentless or nearly so. Slow streams, especially W.

III. NELUMBO Adans.

Rootstock large and stout. Leaves round, shield-shaped, often raised above the water. Flowers large, raised above water at first, but often submerged after blooming. Sepals and petals hypogynous, numerous, the inner sepals and outer petals not distinguishable from each other. Stamens many, hypogynous. Pistils several, 1-ovuled, borne in pits in the flattish upper surface of a top-shaped receptacle, which enlarges greatly in fruit.

1. **N. lutea** Pers. AMERICAN LOTUS, WATER CHINQUAPIN. Rootstock often 3–4 in. in diameter, horizontal. Leaves 1½–2½ ft. broad, prominently ribbed, with much bloom above, often downy beneath. Petioles and peduncles stout. Flowers pale yellow, 5–9 in. broad. Sepals and petals falling quickly. Fruit top-shaped, 3–4 in. in diameter; the seeds ½ in. in diameter. In ponds and slow-running streams W., introduced from the Southwest.*

33. RANUNCULACEÆ. BUTTERCUP FAMILY

Herbs, rarely shrubs, usually with biting or bitter juice. Leaves basal or alternate (in *Clematis* opposite; stem leaves or involucre whorled in *Anemone*); stipules none or adnate to the petiole. Floral organs all distinct and unconnected. Sepals 5 or more (rarely 2–4), falling early, often petal-like. Petals none, or 5 or more (rarely 3). Stamens many. Carpels many, 1-celled; stigmas simple; ovules 1 or more. Fruit composed of 1-seeded akenes or many-seeded follicles. Seeds small.

A

Flowers zygomorphic.

With a spur. Delphinium, XII
With a hood. Aconitum, XIII

B

Flowers actinomorphic.

1. Petals present (in (*c*) not very unlike the stamens).
   (*a*) Petals very large and showy. Pæonia, IX
   (*b*) Petals small, tubular at the tip. Coptis, X
   (*c*) Petals narrow, spatulate, on slender claws. Actæa, XIV
   (*d*) Petals prolonged backward into spurs. Aquilegia, XI
   (*e*) Petals flat, with a little scale at the base, inside. Ranunculus, I

Cut a thin section at right angles to the skin and examine with a high power. Moisten the section with iodine solution and examine again.

If possible, secure a potato which has been sprouting in a warm place for a month or more (the longer the better), and look near the origins of the sprouts for evidences of the loss of material from the tuber.

EXPERIMENT XII

Use of the Corky Layer. — Carefully weigh a potato, then pare another larger one, and cut portions from it until its weight is made approximately equal to that of the first one. Expose both freely to the air for some days and reweigh. What does the result show in regard to the use of the corky layer of the skin?

99. Morphology of the Potato. — It is evident that in the potato we have to do with a very greatly modified form of stem. The corky layer of the bark is well represented, and the loose cellular layer beneath is very greatly developed; wood is almost lacking, being present only in the very narrow ring which was stained by the red ink, but the pith is greatly developed and constitutes the principal bulk of the tuber. All this is readily understood if we consider that the tuber, buried in and supported by the earth, does not need the kinds of tissue which give strength, but only those which are well adapted to store the requisite amount of food.

100. Structure of a Bulb; the Onion. — Examine the external appearance of the onion and observe the thin membranaceous skin which covers it. This skin consists of the broad sheathing bases of the outer leaves which grew on the onion plant during the summer. Remove these and notice the thick scales (also formed from bases of leaves as shown in Fig. 35) which make up the substance of the bulb.

Make a transverse section of the onion at about the middle and sketch the rings of which it is composed. Cut a thin section from the interior of the bulb, examine with a moderate power of the microscope, and note the thin-walled cells of which it is composed.

Split another onion from top to bottom and try to find:

(*a*) The *plate* or broad flattened stem inside at the base (Fig. 34).

(*b*) The central bud.

(*c*) The bulb-scales.

(*d*) In some onions (particularly large, irregular ones) the bulblets or side buds arising in the axes of the scales near the base.

Test the cut surface for starch.

101. Plant-Foods in the Onion. — *Grape sugar* is an important substance among those stored for food by the plant. It received its name from the fact that it was formerly obtained for chemical examination from grapes. Old, dry raisins usually show little masses of whitish material scattered over the skin which are nearly pure grape sugar. Commercially it is now manufactured on an enormous scale from starch by boiling with diluted hydrochloric acid. In the plant it is made from starch by processes as yet imperfectly understood, and another sugar, called *maltose*, is made from starch in the seed during germination.

It may be readily shown by suitable experiments that the onion contains both grape sugar and proteids.

102. Tabular Review of Experiments. — [Continue the table from Sect. 38.]

103. Review Summary of Work of Stem.

Channels for upward movement of water	in young dicotyledonous stems. in dicotyledonous stems several years old. in monocotyledonous stems.
Channels for downward movement of water	in dicotyledonous stems. in monocotyledonous stems.
Channels for transverse movements.	
Storage of plant-food	where stored. kinds stored. uses.

1. **T. dioicum** L. Early Meadow Rue. Plant 1–2 ft. high, smooth and pale or with a bloom. Leaves all petioled, most of them thrice compound in threes; leaflets thin and delicate, roundish, 3–7-lobed. Flowers in slender panicles, purplish or greenish; staminate ones with slender, thread-like filaments, from which hang the conspicuous yellowish anthers. Rocky woods and hillsides.

2. **T. polygamum** Muhl. Tall Meadow Rue. Stems from fibrous roots, tall and coarse, nearly or quite smooth, 4–8 ft. tall. Leaves twice compound, those of the stem sessile, the others long-petioled; leaflets oval or oblong, often cordate, smooth or downy beneath, quite variable in size on the same plant. Flowers small, in large panicles. Sepals 4 or 5, white. Filaments club-shaped. Akenes short-stalked. Thickets and meadows E.

III. ANEMONELLA Spach. (SYNDESMON)

Small, perennial herbs. Leaves compound, smooth, the basal ones long-petioled, those of the stem sessile. Flowers in a terminal umbel, slender-pediceled. Sepals petal-like. Petals none. Pistils 4–15; stigmas sessile, truncate.*

1. **A. thalictroides** Spach. Rue Anemone. Stem slender, 6–10 in. high, from a cluster of tuberous roots. Basal leaves long-petioled, twice compound in threes; leaflets oval, heart-shaped, 3–5-lobed. Stem leaves 2–3 compound in threes, whorled, the long-stalked leaflets veiny, forming an involucre of 6–9 apparently simple leaves. Flowers 3–6 in an umbel, $\frac{1}{2}$–$\frac{3}{4}$ in. wide; sepals 6–10, white. In rich woods.*

IV. HEPATICA Hill

Involucre of 3 small, simple leaves, so close to the flower as to look like a calyx. Leaves all basal, 3-lobed, heart-shaped, thick, and evergreen, purplish-red beneath. Flowers single, on rather slender hairy scapes.

1. **H. triloba** Chaix. Round-Lobed Hepatica. Lobes of the leaves obtuse or rounded; those of the involucre obtuse; sepals 6–12, varying from blue to white.

2. **H. acutiloba** DC. Sharp Lobed Hepatica. Closely similar to the former, except for the acute lobes of the leaves and tips of the involucre.

[Both species have many local names, such as Liverleaf, Liverwort, Noble Liverwort, Spring Beauty.]

V. ANEMONE L.

Perennial herbs, usually with basal leaves, and 2 or 3 opposite or whorled stem leaves, constituting an involucre some distance below the flower or flower cluster. Sepals few or numerous, colored and petal-like. Petals usually wanting. Akenes pointed, or with long, feathery tails.

1. A. patens L., var. **Wolfgangiana.** PASQUE FLOWER. Low plants, 1 in.–1 ft. high, clothed with long, silky hairs. Leaves divided in threes. Flower single, large, showy, pale-purplish, borne on a peduncle developed before the leaves. Carpels many, with long, hairy styles, which in fruit form tails 2 in. long. Prairies and bluffs, N.W.

2. A. caroliniana Walt. CAROLINA ANEMONE. Stem simple, from a roundish tuber, slightly downy, 6–12 in. high, bearing a single flower about 1 in. broad. Basal leaves 2–3, long-petioled, compound in threes, the divisions cut or lobed; stem leaves sessile, compound in threes, the divisions wedge-shaped. Sepals 12–20, white; head of fruit becoming oblong; akenes woolly. In open woods W.*

3. A. cylindrica Gray. LONG-FRUITED ANEMONE. Plants about 2 ft. high, branching, with an involucre of long-petioled, divided, and cleft leaves, from within which spring several long, naked peduncles. Flowers greenish-white. Sepals obtuse. Head of fruit cylindrical, composed of very many densely woolly akenes. Dry woods and prairies.

4. A. virginiana L. Plant hairy, 2–3 ft. high. Peduncles 6–12 in. long, sometimes forking, the first ones naked, the later ones with a little 2-leaved involucre at the middle. Leaves of the involucre 3, each 3-parted, the divisions ovate-lanceolate, pointed. Sepals acute. Head of fruit ovoid. Woods and meadows.

5. A. canadensis L. Plant hairy, rather low. Peduncle arising from a 3-leaved primary involucre, then branching, each branch bearing at the middle a 2-leaved secondary involucre. Leaves of the primary involucre broadly wedge-shaped, 3-cleft, the divisions cut and toothed. Sepals obovate, white. Head of fruit spherical. In low ground or woods.

6. A. quinquefolia L. WIND FLOWER, WOOD ANEMONE. Stem simple, from a thread-like rootstock; involucre of 3 leaves, each petioled, and of 3 leaflets, which are cut, toothed, or parted. Peduncle 1-flowered. Sepals 4–7, white, often tinged with purple outside. Carpels 15 or 20. This species is very nearly related to, but now regarded as distinct from, the European *A. nemorosa.*

VI. CLEMATIS L.

Perennial herbs or slightly woody vines, usually climbing by the leafstalks. Leaves opposite, simple or compound. Sepals 4, petal-like. Petals very small or wanting. Pistils numerous, tipped by the persistent styles, which often become long and plumose in fruit.*

1. C. crispa L. MARSH CLEMATIS. Stem climbing, a little woody below, slightly downy above, 3–5 ft. high. Leaves pinnately compound; leaflets 5–7, varying from lanceolate to ovate, thin, entire or 3–5-lobed. Flowers showy, perfect, solitary, on long axillary peduncles. Sepals lanceolate, taper-pointed, thick, wavy on the margins, twice the length of the stamens, light bluish-purple, 1–1½ in. in length. Tails of the ripened akenes 1 in. long, silky. Rich woods and river banks S.*

2. C. Viorna L. LEATHER FLOWER. Stem climbing, nearly smooth, 6–10 ft. long. Leaves usually pinnately compound, the lowest pair often compound in threes and the upper pair simple. Leaflets usually 5–7, oblong-ovate or oval, acute, firm, entire or lobed. Calyx bell-shaped, nodding; sepals ovate, taper-pointed with a short, recurved point, thick and leathery, reddish-purple, 1 in. long. Tails of the akenes plumose, 1½ in. long, brownish. On river banks and rich soil.*

VII. ISOPYRUM L.

Small, smooth herbs. Leaves 2–3 times compound, in threes; the leaflets 2–3-lobed. Flowers peduncled, white. Sepals 5, petal-like, soon falling. Petals wanting (in our species). Stamens 10–40. Pistils 3–6 or more.

1. I. biternatum T. & G. A delicate, erect plant, with alternate branches, looking much like *Anemonella*, with clustered stems from perennial tuberous roots. Damp woods.

VIII. CALTHA L.

Smooth perennials with large, roundish leaves. Sepals petal-like, 5–9. Petals none. Pistils 5–10, each consisting of a 1-celled ovary with a nearly sessile stigma. Fruit a many-seeded follicle.

1. C. palustris L. MARSH MARIGOLD, COWSLIPS, MEADOW BUTTERCUP (both the latter unsuitable names, but in common use). Stem hollow, smooth, ascending; leaves smooth, roundish and heart-shaped, or kidney-shaped, with crenate, dentate, or nearly entire margins; the broad oval sepals bright yellow. Swamps or wet ground.

IX. PÆONIA L.

Perennial, from thick, fleshy roots; stems shrubby or herbaceous. Leaves much divided. Flowers terminal, large and showy. Sepals 5, leaf-like and persistent. Petals 5 or more. Pistils 3–5; ovaries surrounded by a disk.*

1. **P. officinalis** L. GARDEN PEONY. Herbaceous; flowering stems 1–2 ft. high. Leaves ample; leaflets lance-ovate, cut or incised, smooth. Flowers double, white or red. Follicles 2, erect, many-seeded. Common in gardens.*

X. COPTIS Salisb.

Low, smooth perennials, with 3-divided basal leaves. Flowers small, white, on scapes. Sepals 5–7, petal-like, soon falling. Petals 5–7, small, club-shaped, tubular at the apex. Stamens 15–25. Pistils 3–7, stalked. Pods thin and dry, 4–8-seeded.

1. **C. trifolia** Salisb. GOLD THREAD. A pretty, delicate plant, with slender, 1-flowered scapes, from long, bright-yellow, thread-like rootstocks, which are bitter and somewhat medicinal. Leaves later than the flowers, each of 3 wedge-shaped leaflets, which finally become shining and evergeen. Damp, cold woods and bogs.

XI. AQUILEGIA L.

Perennials, with leaves twice or thrice palmately compound, the divisions in threes.

Sepals 5, petal-like, all similar. Petals 5, all similar, each consisting of an expanded portion, prolonged backward into a hollow spur, the whole much longer than the calyx. Pistils 5, forming many-seeded pods.

1. **A. canadensis** L. WILD COLUMBINE. Flowers scarlet without, yellow within, nodding; spurs rather long.
2. **A. vulgaris** L. GARDEN COLUMBINE. Flowers often double, and white, blue, or purple. Spurs shorter and more hooked. Cultivated from Europe, and sometimes become wild.

XII. DELPHINIUM L.

Annual or perennial herbs. Stem erect, simple or branched. Leaves alternate, petioled, palmately divided. Flowers in terminal racemes or panicles, showy. Sepals 5, colored, irregular, the upper one prolonged into a spur. Petals 4, unequal, the two upper ones with long spurs which are inclosed in the spur of the upper sepal, the other two short-stalked. Pistils 1–5; ovaries many-seeded.*

1. **D. tricorne** Michx. DWARF LARKSPUR. Perennial. Stem simple, from a tuberous root, usually low (½–1 ft. high), but sometimes 2 ft. high. Leaves deeply 5-parted, the divisions irregularly 3–5-cleft. Racemes few-flowered, loose. Flowers blue, sometimes white. Pods diverging. Southward.

2. **D. azureum** Michx. BLUE LARKSPUR. Perennial. Stem usually simple, slender, downy, 1–2 ft. high. Leaves 2–3 in. wide, 3–5-parted, the divisions cleft into 3–5 narrow, toothed, or entire lobes. Flowers in a strict, many-flowered, terminal raceme, showy, blue or whitish. Spur ascending, curved; lower petals bearded, 2-cleft. Pods erect. On rich or rocky soil in open places, N.*

XIII. ACONITUM L.

Erect, perennial herbs. Leaves alternate, palmately lobed or cut. Flowers irregular, in panicles or racemes. Sepals 5, the back one large, arched, and hooded, the front one the narrower. Petals 2–5, small, the 2 back ones clawed and covered by the hood of the sepals; 3 lateral ones small or wanting. Follicles 3–5. Seeds many, wrinkled.

1. **A. Napellus** L. MONKSHOOD. An erect, poisonous plant, 1–2 ft. high. Raceme simple and densely flowered. Flowers dark blue. Cultivated from Europe.

Several native species of *Aconitum* occur within our limits, but they are not common.

XIV. ACTÆA L.

Perennial. Stem simple. Leaves 2–3, compound in threes; leaflets ovate, sharply cut or toothed. Flowers white, in a short and thick terminal raceme. Sepals 4–5, soon deciduous. Petals 4–10, small. Pistil single; stigma 2-lobed. Fruit a many-seeded berry.*

1. **A. rubra** Willd. RED BANEBERRY. Stem about 2 ft. high. Raceme ovoid or hemispherical. Petals acute. Pedicels slender. Berries usually red, sometimes white, ovoid. Common N.

2. A. alba Miller. BANEBERRY. Stem erect, smooth or nearly so, 18–24 in. high. Leaves large and spreading; leaflets thin. Racemes very broad. Petals slender, truncate. Pedicels red, thickened in fruiting; berries white. In rich woods, more common S.*

34. BERBERIDACEÆ. BARBERRY FAMILY

Herbs or shrubs. Leaves alternate, simple or compound, usually without stipules. Sepals petal-like. Petals hypogynous, distinct, their number some multiple of 2, 3, or 4, never of 5. Stamens usually one opposite each petal; anthers commonly opening by 2 uplifted lids (the stamens of *Podophyllum* are exceptional). Pistil 1, 1-celled; ovules 2 or more. Fruit a berry or capsule.

I. PODOPHYLLUM L.

Perennial. Stem simple, smooth, erect, 12–15 in. tall, bearing 2 leaves with a large white flower between them. Sepals 6, falling off as the flower opens. Petals 6–9, obovate. Stamens twice as many as the petals; anthers splitting open lengthwise. Pistil 1; stigma large, flat, sessile. Fruit berry-like, 1-celled, many-seeded.*

1. P. peltatum L. MAY APPLE. Rootstock rather large. Leaves orbicular, shield-shaped, 5–9-lobed and toothed, smooth, 9–12 in. wide. Flowers 1–2 in. wide, on a peduncle 1–2 in. long. Stamens prominent; anthers opening longitudinally. Fruit 1½–2 in. long, oval, fragrant, edible; each seed surrounded by a pulpy covering. In rich woods. The roots and leaves are used in medicine.*

II. CAULOPHYLLUM Michx.

A perennial smooth herb, 1–2½ ft. high. Leaf large, single, sessile, thrice compound in threes, borne high up on the stem; there is also a large, very compound basal leaf. Flowers racemed or panicled, yellowish-green. Sepals 6, with 3 bractlets. Petals 6, gland-like, somewhat curved inward at the tip, much smaller than the sepals. Pistil 2-ovuled, the ovary soon bursting open and leaving the 2 blue seeds to ripen naked.

1. C. thalictroides Michx. BLUE COHOSH, PAPPOOSE ROOT. Whole plant purplish and covered with a bloom when young. Flowers appearing before the leaf is fully developed. Rich woods.

III. BERBERIS L.

Spiny shrubs with yellow wood. Leaves spinous-toothed, jointed on the very short petiole, often reduced to 3–7-cleft spines. Flowers in racemes, solitary or in pairs. Sepals 8–9, the outer minute. Petals 6, each with 2 nectar glands at the base. Stamens 6. Ovules few. Berry 1–2-seeded ; seeds bony-coated.

1. **B. vulgaris** L. COMMON BARBERRY. A shrub 4–6 ft. high. Leaves obovate, spinous-serrate; those on the old shoots mere spines. Flowers pale yellow, in drooping racemes. Stamens irritable, closing quickly toward the center of the flower when touched. Berry ½ in. long, nearly ellipsoidal in shape, scarlet or orange-scarlet, very acid, eatable when cooked. Cultivated from Europe and introduced in eastern New England and locally in the upper Mississippi Valley.

2. **B. Thunbergii** DC. A low shrub. Leaves entire, turning red and remaining so for a considerable time in autumn. Flowers solitary or in pairs. Berries bright red, remaining on the branches all winter. Cultivated from Japan.

35. MAGNOLIACEÆ. MAGNOLIA FAMILY

Trees or shrubs. Leaves alternate, not toothed or serrate. Flowers solitary, large and showy. Floral envelopes and stamens hypogynous. Calyx and corolla colored alike, the parts of the perianth forming 3 or more circles of 3 parts each. Stamens many. Carpels many, usually joined over the long receptacle and forming a sort of cone-shaped fruit, which may be either fleshy or dry.

I. MAGNOLIA L.

Aromatic trees or shrubs. Leaves alternate, often in clusters at the ends of the branches, entire, usually thick and leathery ; stipules large, quickly deciduous. Flowers terminal, showy, bisexual. Sepals 3, caducous. Petals 6–12, in 2–4 rows, concave. Stamens numerous. Ovaries numerous, 1-celled, 2-seeded, the mature follicles opening at the beak and the fleshy seeds remaining for some time suspended by slender threads.*

1. **M. virginiana** L. SWEET BAY. A small tree with light gray bark. Leaves scattered on the branches, evergreen, thick and leathery, oval or oblong, smooth and green above, white and with

a bloom, downy beneath, 4–6 in. long. Flowers white, fragrant, 2–3 in. in diameter; petals 9, concave. Cone 1½–2 in. long, pink. Common in swamps and along streams, New York and southward (a few in eastern Massachusetts). The leaves often used in flavoring soups, etc.

2. M. acuminata L. CUCUMBER TREE. A tree 60–90 ft. high. Leaves thin, oblong or oval, acute, light green and somewhat downy beneath, 5–10 in. long. Flowers oblong-bell-shaped, greenish-yellow, 2 in. long. Petals much longer than the sepals. Cone of fruit 2–3 in. long, often curved, cylindrical. Woods, especially S.

3. M. macrophylla Michx. LARGE-LEAVED UMBRELLA TREE. A small tree with gray bark. Leaves clustered at the ends of the branches, oblong or obovate, obtuse at the apex, cordate at the base, green and glabrous above, white and downy beneath, 1½–3 ft. long; petioles stout. Flowers white with a purple center, fragrant, 8-12 in. wide. Petals oblong, obtuse, two or three times as long as the sepals. Cone ovate, 4–6 in. long, bright red at maturity. Shady woods on light soil S.*

4. M. Fraseri Walt. EAR-LEAVED UMBRELLA TREE. A small tree with a slender trunk and widely spreading branches. Leaves clustered at the ends of the branches, deciduous, oblong or obovate, contracted, cordate and eared at the base, smooth on both sides, 8–12 in. long; petioles slender. Flowers white and fragrant, 6 in. broad. Petals longer than the sepals, spatulate or oblong, obtuse at the apex, narrowed at the base. Cone 3–4 in. long, pink at maturity. In rich woods S.*

II. LIRIODENDRON L.

A large tree with rough, dark-colored bark. Leaves scattered on the branches, deciduous, 3-lobed, truncate, stipuled, petioled. Flowers bisexual. Sepals 3, reflexed. Petals 6, erect. Stamens numerous. Ovaries numerous, 2-ovuled, joined over each other on the elongated receptacle, never opening, deciduous.*

1. L. tulipifera L. TULIP TREE. The largest tree in the family. Leaves roundish in outline, mostly 3-lobed, the terminal lobe truncate or broadly notched, usually heart-shaped at the base, smooth, green above, lighter beneath; petioles slender. Flowers terminal, bell-shaped, greenish-yellow marked with orange. Petals obovate, obtuse, about as long as the sepals. Mature cones ovate, acute, 2–3 in. long. Common on low ground, Pennsylvania and S. Often called "white wood," or, incorrectly, "white poplar." Wood valuable for making boxes and light furniture.*

36. CALYCANTHACEÆ. Calycanthus Family

Shrubs. Leaves opposite, entire, without stipules. Flowers solitary, often sweet-scented. Sepals and petals numerous, the outer sepals bract-like. Stamens many, short, the inner ones usually sterile. Ovaries several, inserted on the inside of an irregular, hollow, pear-shaped receptacle something like a large rose hip, forming 1-seeded akenes in fruit.

CALYCANTHUS L. (BUTNERIA)

Shrubs, 4–8 ft. tall; branches opposite. Leaves oval, downy beneath, short-petioled; both leaves and bark aromatic. Sepals and petals many, in several rows, somewhat fleshy, indistinguishable. Pistils several, inserted on the inner side of the persistent calyx tube. Mature fruit pear-shaped, dry, inclosing the akenes.*

1. C. floridus L. Sweet-Scented Shrub, Strawberry Bush, Spice Bush, Shrub. A widespreading bush, 4–8 ft. high; twigs downy. Leaves oval or oblong, acute or taper-pointed, rough above, downy beneath, 2–3 in. long. Flowers 1 in. wide, brownish-purple, very fragrant. Sepals united below to form a cup, on the inside of which the other parts of the flower are inserted; cup leafy-bracted on the outside. Banks of streams and rich hillsides S., often cultivated.*

37. ANNONACEÆ. Papaw Family

Trees or shrubs. Leaves alternate, entire, pinnately veined. Flowers bisexual, hypogynous, axillary, solitary. Calyx of 3 sepals; corolla of 6 thickish petals in 2 rows. Stamens many; filaments very short. Pistils several or many, becoming fleshy or pulpy in fruit.

ASIMINA Adans.

Shrubs or small trees. Leaves deciduous. Flowers nodding. Sepals 3, ovate. Petals 6, the 3 outer ones larger and spreading. Stamens very numerous, crowded on the globular receptacle. Ovaries 3–15, sessile, 1-celled, several-ovuled. Fruit a large, fleshy, oblong berry; seeds large, horizontal.*

1. A. triloba Dunal. Papaw. A small tree, 10–20 ft. high; bark nearly smooth, lead-colored. Leaves oblong-obovate, acute at the apex, obtuse at the base, rusty-downy when young and becoming smoother with age, 6–10 in. long. Flowers on branches of the previous season, appearing before or with the leaves; the short peduncles and the sepals brown-downy; petals purple, obovate, 3–4 times longer than the sepals. Fruit 3–5 in. long, edible when ripe. Common on banks of streams, especially S. and S.W. The bark is very tough and is often used in the place of rope.*

38. LAURACEÆ. Laurel Family

Aromatic plants, nearly always trees or shrubs. Leaves alternate, simple, usually entire, and marked with translucent dots. Calyx regular, hypogynous, of 4 or 6 colored sepals. Stamens in 3 or 4 circles of 3 each, the anthers opening by valves. Style single. Fruit a 1-seeded berry or drupe.

I. SASSAFRAS Nees.

A tree with rough, yellowish bark and a spreading top. Leaves deciduous, entire or 2–3-lobed. Flowers diœcious, involucrate, at the end of the twigs of the previous season. Calyx 6-parted, persistent in the pistillate flowers. Stamens 9, in 3 rows. Pistillate flowers with 4–6 abortive stamens and a single ovary. Fruit a drupe.*

1. S. variifolium Ktze. Sassafras. A tree, usually small and slender, but sometimes with a trunk 3 ft. in diameter and 125 ft. high. Leaves oval, entire, mitten-shaped or 3-lobed, downy when young but becoming smooth with age, dark green above, paler below, petiolate. Racemes several in a cluster, peduncled; flowers yellow. Stamens about as long as the sepals. Fruit dark blue, ovoid, on thickened red pedicels. All parts of the tree aromatic. Trees producing pistillate flowers rare. Common. The wood is valuable for cabinet making, and an aromatic oil is extracted from the bark.*

II. BENZOIN Fabric.

Shrubs. Leaves deciduous, entire. Flowers in lateral, sessile clusters, appearing before the leaves, diœcious or somewhat monœcious. Involucre of 4 scales. Stamens 9 in the staminate flowers; filaments slender. Pistillate flowers with 12–15 abortive stamens and a single globose ovary with a short style.*

1. **B. æstivale** Nees. Spice Bush. A shrub, 5–15 ft. high, with smooth bark and slender twigs. Leaves oblong-obovate, acute at the base, pale and downy beneath, becoming smooth when old; petioles short. Flowers about as long as the pedicels, yellow, very fragrant. Ovary about as long as the style. Fruit an obovoid, red drupe, about ⅓ in. long, on a slender pedicel. Banks of streams and damp woods. Twigs and leaves quite aromatic.*

39. PAPAVERACEÆ. Poppy Family

Annual or perennial herbs, often with milky juice. Leaves sometimes all basal; stem leaves usually alternate without stipules. Flowers bisexual, regular or irregular. Sepals usually 2, shed as the flower opens. Petals 4–12, falling early. Stamens numerous or 6 (in 2 sets), 4, or 2. Carpels 2–16. Fruit a capsule.

I. ESCHSCHOLTZIA Cham.

Annual or perennial herbs. Leaves pale or bluish-green, usually cut into very narrow divisions. Sepals united into a pointed cap, which falls off in one piece as the flower opens. Petals 4, orange or yellow. Stamens many, with long anthers. Stigmas 2–6, spreading. Pods long and slender, grooved. Receptacle often surrounded by a rim on which the calyx rests.

1. **E. californica** Cham. Annual or perennial, with rather succulent leafy stems. Flowers large and showy, yellow or orange-yellow. Receptacle top-shaped, with a broad rim. Cultivated from California.

II. SANGUINARIA L.

Perennial. Rootstock thick, horizontal; joints and scars of previous growths persistent several years; juice orange-colored. Leaves on long petioles, kidney-shaped. Scape 1-flowered. Sepals 2, falling off as the flower opens. Petals 8–12. Ovary 1; stigmas 2. Capsule oblong, seeds crested.*

1. **S. canadensis** L. Bloodroot. Leaves and scape with a bloom; leaves palmately 5–9-lobed, lobes rounded or toothed; scapes naked, nearly as long as the petioles. Flowers white, 1 in. or more wide.

Petals oblong or obovate, quickly deciduous. Capsule 1-celled, 2-valved, the valves separating from the persistent placentæ at maturity. In rich, open woods.*

III. CHELIDONIUM L.

Erect, branched, perennial herbs, with yellow juice. Leaves much divided. Flowers yellow. Sepals 2, falling as the flower opens. Petals 4. Ovary 1-celled; style dilated at the top, with 2 joined stigmas. Capsule linear.

1. C. majus L. CELANDINE. Stem 1–2 ft. high, brittle, slightly hairy, leafy. Leaves once or twice pinnate. Flowers small. A rather common weed in yards and along fences. Naturalized from Europe.

IV. PAPAVER L.

Annual or perennial herbs with milky juice. Stem erect, smooth, or rough-hairy, branching above. Leaves more or less lobed or dissected. Flower buds nodding, flowers showy. Sepals commonly 2, falling off as the flower opens. Petals 4–6. Stamens many. Stigma disk-like; ovules many, borne on many inwardly projecting placentæ.* .

1. P. somniferum L. OPIUM POPPY. Annual. Stem erect, branched above, smooth and with a bloom, 2–3 ft. high. Leaves oblong, irregularly lobed or cut, sessile, clasping. Flowers nearly white, with a purple center, large and showy, on long peduncles. Capsule globose, seeds minutely pitted. About old gardens and waste places. Cultivated in southern Asia, where the juice of the capsules is dried to make opium.*

2. P. Rhœas L. CORN POPPY. Annual. Stem erect, hairy, 1–3 ft. high. Lower leaves petioled, upper ones sessile, all pinnately cut, the lobes serrate. Corolla scarlet, often with a dark center, 2–4 in. in diameter. Capsule smooth, obovoid. Waste ground, sometimes in fields. Introduced from Europe and often cultivated.

3. P. dubium L. SMOOTH-FRUITED POPPY. Annual. Stem slender, branching, 1–2 ft. tall. Leaves pinnatifid, the lower petioled, the upper sessile. Flowers large and showy, usually red; capsule long-obovoid, smooth. In cultivated ground. Both this and No. 1 are often cultivated in gardens and produce double flowers.*

4. P. orientale L. ORIENTAL POPPY. A large, rough-hairy perennial. Leaves large, deep green, almost pinnate. Flower very large, deep red. Cultivated from the eastern Mediterranean region.

5. P. nudicaule L. ICELAND POPPY. A delicate but rough-hairy perennial plant. Leaves all basal, pale, pinnately cut. Flowers yellow-orange or white, borne singly on rather slender, hairy scapes. Cultivated from Europe.

V. ADLUMIA Raf.

A delicate climbing biennial. Leaves thrice-pinnate, cut-lobed. Sepals 2, very small. Petals 4, all united into a corolla which is slightly heart-shaped or 2-knobbed at the base, remaining as a spongy covering over the small, few-seeded pod.

1. A. fungosa Greene. MOUNTAIN FRINGE, ALLEGHENY VINE. Climbing several feet high by the leafstalks. Flowers pinkish-white. Rocky hillsides, often cultivated.

VI. DICENTRA Bernh. (BICUCULLA)

Smooth, delicate herbs, with watery juice. Leaves compound in threes and finely cut. Flowers racemed, nodding. Sepals 2, small and scale-like. Petals 4, slightly united to form a heart-shaped or 2-spurred corolla (Fig. 17), the inner pair spoon-

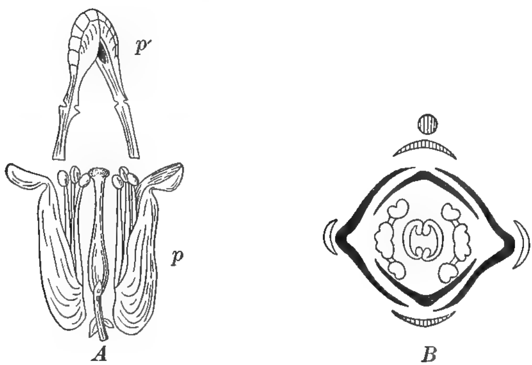


FIG. 17. Flower of *Dicentra*

A, view of flower partly dissected: *p*, the larger outer petals; *p′*, the spoon-shaped inner petals. *B*, floral diagram. (After Le Maout and Decaisne)

shaped, inclosing the stamens and pistil. Stamens 6; the filaments somewhat united into 2 sets, and the anthers in 2 sets close to the stigma. Stigma 2-crested. Pod 10–20-seeded.

1. **D. Cucullaria** Bernh. Dutchman's Breeches, Breeches Flower. A low, stemless perennial, with a delicate scape and a cluster of basal leaves with linear divisions, from a sort of bulb made of small, scaly grains. Flowers in a 4–10-flowered simple raceme, not fragrant. Spurs of the corolla longer than the pedicels; corolla mostly white with a yellowish tip. Rich woods, common.

2. **D. canadensis** Walp. Squirrel Corn, Wild Hyacinth. A low, stemless perennial, with scape and leaves much as in No. 1, and with small yellow tubers looking like grains of corn scattered along the underground shoots. Corolla only heart-shaped at the base, whitish or flesh-colored, very fragrant. Rich woods.

3. **D. spectabilis** Lem. Bleeding Heart, Ear Drops. Stems branching, recurved. Leaves large, twice compound in threes, the divisions rather broad, like those of the common peony. Racemes long, drooping, many-flowered. Flowers large, heart-shaped, bright pink. Cultivated from China.

VII. CORYDALIS Medic. (CAPNOIDES)

Leafy-stemmed biennial herbs (the American species). Leaves much divided, alternate or nearly opposite. Racemes terminal or opposite the leaves. Sepals 2, small. Petals 4; corolla with a single spur at the base, on the upper side. Capsule many-seeded.

1. **C. sempervirens** L. Pale Corydalis. Plant erect, covered with a bloom. Flowers pink-purple with yellow tips. Spur of the corolla very short and rounded. Rocky woods.

2. **C. aurea** Willd. Golden Corydalis. A low, spreading plant, finally ascending. Corolla bright yellow, 1–2 in. long; the spur shorter than the pedicel, somewhat bent. Shaded, rocky banks.

40. CRUCIFERÆ. Mustard Family

Herbs with pungent, watery juice, and alternate leaves without stipules. Sepals 4, often falling off early. Petals usually 4, arranged in the form of a cross. Stamens 6, the 2 outer ones shorter than the 4 inner ones. Fruit generally a pod, divided into 2 cells by a thin partition which stretches across from one to the other of the 2 placentæ. The flowers throughout the family are so much alike that the genera and species cannot usually be determined without examining the tolerably mature fruit.

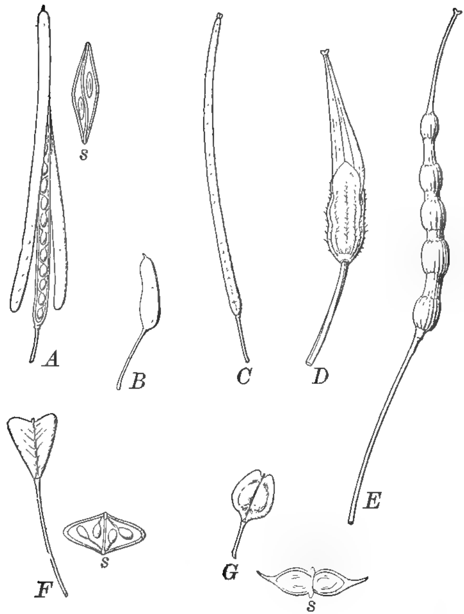


FIG. 18. Types of pods of *Cruciferæ*

A, flattened pod of *Arabis*, seeds in a single row in each cell: *s*, cross section of pod, showing flattening parallel to the partition. *B*, pod of *Radicula palustris*, seeds in several rows. *C*, nearly cylindrical pod of *Sisymbrium*. *D*, beaked pod of white mustard (*Sinapis alba*). *E*, dried necklace-shaped and beaked pod of radish (*Raphanus Raphanistrum*). *F*, flattened pod of shepherd's purse (*Capsella Bursa-pastoris*): *s*, cross section, showing flattening at right angles to the partition. *G*, flattened pod of *Lepidium campestre*; *s*, cross section, showing flattening at right angles to the partition. (The pods natural size, the sections somewhat magnified.) (After Cosson and De Saint-Pierre)

A

Pods short and flattened, contrary to the partition, splitting open when ripe.

Pod roundish. Lepidium, IV

Pod triangular, inversely heart-shaped. Capsella, V

B

Pods globular or cylindrical, splitting open when ripe.

(*a*) Pods globular. Flowers yellow. Lesquerella, III (*b*) Pods cylindrical; seeds ellipsoid. Flowers very small, yellow. Sisymbrium, VIII

(*c*) Pods cylindrical; seeds globular. Flowers of moderate size, yellow. Brassica, VII

(*d*) Pods cylindrical; seeds in 2 rows; flowers white. Or pods ovoid or ellipsoid; flower yellowish. Aquatic plants, or growing in wet soil. Radicula, IX

(*e*) Pods cylindrical or angled; seeds in a single row, flattened. Flowers yellow. Barbarea, X

C

Pods elongated, often jointed, tapering toward the tip, never splitting open. Raphanus, VI

D

Pods flattened parallel to the partition, splitting open when ripe.

(*a*) Wild species; leafy-stemmed; growing in or near water. Pods linear. Cardamine, XII

(*b*) Wild species; stems naked below, bearing only 2 or 3 leaves. Pods lanceolate. Dentaria, XI

(*c*) Wild species; leafy-stemmed: growing on dry ground or rocks. Pods linear; seeds usually winged or margined. Arabis, XIII

(*d*) Cultivated species. Pods round or roundish. Lobularia, I

(*e*) Cultivated species; covered with a grayish down of star-shaped hairs. Pods cylindrical. Matthiola, II

I. LOBULARIA Desv. (KONIGA)

Perennial, though usually growing as an annual. Stems branching, diffuse; branches slender. Leaves small, entire, downy, with forked hairs. Flowers small, white, in numerous terminal racemes. Petals obovate, entire, twice as long as the sepals. Filaments enlarged below. Pod round, compressed; seeds 1 in each cell.*

1. L. maritima Desv. SWEET ALYSSUM. Stem weak, diffuse, ascending, minutely downy. Lower leaves narrowed into a petiole, the upper sessile. Racemes erect, many-flowered. Flowers fragrant, pedicels ascending. Pod often pointed. Common in cultivation and often run wild.*

II. MATTHIOLA R. Br.

Herbaceous or shrubby oriental plants, covered with a down composed of star-shaped hairs. Flowers in showy racemes of many colors, ranging from white to crimson. Stigmas large and spreading. Pods nearly cylindrical, except for a prominent midrib on each valve.

1. **M. incana** R. Br. COMMON STOCK, GILLYFLOWER. Biennial or perennial, with somewhat woody stems. Cultivated in greenhouses and gardens.

III. LESQUERELLA Wats.

Low herbs with stellate hairs. Leaves simple. Flowers in racemes, mostly yellow. Pod globular-inflated, with a translucent partition nerved from the apex to the middle. Seeds few, several or many, flattened, marginless or nearly so.

1. **L. globosa** Wats. Annual or biennial. Slender, somewhat branched, 6–20 in. high, covered with fine stellate hairs. Basal leaves 1–1½ in. long, oblong-obovate, obtuse. Stem leaves smaller, linear or oblong, sessile. Raceme finally elongated with thread-like diverging pedicels. Flowers light yellow. Style slender, much longer than the small globose pod. Rocky banks and open places S. and W.

2. **L. argentea** Pursh. SILVERY BLADDER POD. Biennial or perennial, 6–18 in. high, densely stellate-hairy. Leaves linear to oblanceolate, blunt, entire, the lower ones 2–3 in. long. Flowers yellow. Pods downy, on recurved pedicels. Plains W.

IV. LEPIDIUM L.

Annual. Stem erect, or sometimes diffuse. Leaves entire, toothed, or pinnately divided. Flowers in a terminal raceme, small, white. Petals short, sometimes wanting. Stamens 2, 4, or 6. Pod rounded or obcordate, flattened contrary to the partitions.*.

1. **L. virginicum** L. PEPPERGRASS, BIRDS' PEPPER, TONGUE GRASS. Stem erect, smooth, much branched, 1–2 ft. high. Lower leaves obovate in outline, pinnately cut with dentate lobes; upper leaves lanceolate, dentate, slightly downy. Flowers on slender pedicels; petals present, sometimes reduced in the later flowers. Stamens 2. Pod round. A weed growing in waste places.*

2. **L. campestre** R. Br. FIELD CRESS. Annual or biennial. Stem erect, branching above, downy, 8-18 in. high. Basal leaves entire or

pinnately cut toward the base, obtuse; stem leaves oblong or lanceolate, entire or somewhat toothed, with an arrow-shaped clasping base. Flowers white or yellowish, on stout pedicels. Pods ovate, winged, slightly notched, tipped with a very small persistent style. Fields and waste ground, becoming a troublesome weed. Naturalized from Europe.

V. CAPSELLA Medic. (BURSA)

Annual. Stem erect, downy, with branched hairs. Racemes terminal, becoming elongated in fruit. Flowers small, white. Pod obcordate or triangular, flattened contrary to the partition, shorter than the spreading pedicels.*

1. C. Bursa-pastoris Medic. SHEPHERD'S PURSE. Root long and straight. Stem branching above, downy below, smooth above. Lower leaves forming a rosette at the base of the stem, irregularly lobed or pinnately cut; stem leaves lanceolate, clasping, toothed or entire. Sepals downy, about $\frac{1}{2}$ as long as the petals. Pod triangular, notched, or cordate at the apex. Seeds several in each cell. A common weed.*

VI. RAPHANUS L.

Annual or biennial herbs. Basal leaves lyrate. Flowers in long racemes, white or yellow, purple-veined. Sepals erect. Pods rather long, slender-beaked, not splitting open but sometimes breaking across into 1-seeded joints.

1. R. Raphanistrum L. WILD RADISH, JOINTED CHARLOCK. A stout, hairy annual, 1–2 ft. high. Leaves cut into remote segments, which are coarsely toothed or serrate; terminal segment largest. Flowers yellow, turning whitish or purplish. Pods necklace-shaped, and with a long beak. A common weed eastward. Naturalized from Europe.

2. R. sativus L. COMMON RADISH. Similar to No. 1, but with pink or white flowers. Root fleshy, conical or turnip-shaped. Pod fleshy, 2–3-seeded, the beak often longer than the seed-bearing portion. Cultivated from Asia and occasionally self-sown in cultivated ground.

VII. BRASSICA L.

Branching herbs. Leaves often pinnately cut. Flowers in racemes, rather large, yellow. Sepals spreading. Pods nearly cylindrical, sometimes tipped with a beak which does not open. Seeds globular.

1. **B. alba** Boiss. WHITE MUSTARD. Stem 2–5 ft. high, with reflexed hairs. Upper leaves pinnately cut. Pods borne on spreading pedicels, bristly, with a sword-shaped, 1-seeded beak occupying more than half their length. Seeds pale. Cultivated from Europe and introduced to some extent.

2. **B. arvensis** Ktze. CHARLOCK. Stem 1–2 ft. high; it and the leaves rough-hairy. Upper leaves rhombic, barely toothed. Flowers $\frac{1}{2}$–$\frac{3}{4}$ in. across, somewhat corymbed, bright yellow. Pods knotty, spreading, at least $\frac{1}{3}$ of each consisting of a 2-edged, 1-seeded beak. A showy, troublesome weed in grain fields. Naturalized from Europe.

3. **B. juncea** Cosson. Similar to the preceding, but nearly or quite smooth. Pedicels slender. Beak slender, conical, not containing a seed. Naturalized from Asia and becoming very abundant eastward.

4. **B. nigra** Koch. BLACK MUSTARD. Stem 3–6 ft. high, somewhat hairy. Lower leaves lyrate, with the terminal lobe much the longest; stem-leaves linear-lanceolate, entire or toothed, smooth. Pods awl-shaped, 4-angled, smooth, lying against the stem; seeds brownish, more biting than in No. 1. Cultivated from Europe and introduced.

VIII. SISYMBRIUM L.

Annual or biennial herbs. Radical leaves spreading; stem leaves alternate, often eared at the base. Flowers in loose racemes, usually yellow, often bracted. Pods generally narrowly linear, cylindrical, or 4–6-angled; seeds many, ellipsoid, not margined.

1. **S. officinale** Scop., var. **leiocarpum.** HEDGE MUSTARD. Stems branching, stiff. Leaves runcinate-toothed or lobed. Flowers very small, pale yellow. Pods somewhat 6-sided, awl-shaped, smooth, closely pressed against the stem. An unsightly weed in waste ground. Naturalized from Europe.

2. **S. canescens** Nutt. TANSY MUSTARD. Stem 1–2 ft. high. Leaves twice pinnately cut, usually covered with grayish down. Flowers very small, yellowish. Pods oblong, club-shaped, 4-angled, borne on pedicels projecting almost horizontally from the stem, in long racemes. Common westward.

IX. RADICULA Hill. (RORIPA)

Annual or biennial, mostly aquatic plants. Stems erect or diffuse, often widely branching. Leaves simple, pinnately lobed. Flowers small, white or yellow. Sepals spreading.

Stamens 1–6. Pod short and broad or nearly linear; seeds numerous, in 2 rows in each cell.*

1. **R. Nasturtium-aquaticum** B. & R. Watercress. Aquatic herbs. Stems smooth, diffuse, rooting at the joints. Leaves with 3–9 rounded, pinnate lobes, the terminal lobe much the largest. Racemes elongating in fruit. Petals white, twice the length of the sepals. Pods linear, $\frac{1}{2}$–$\frac{3}{4}$ in. long, on slender, spreading pedicels. In ditches and slow streams. Often used for salad.*

2. **R. sinuata** Greene. Spreading Yellow Cress. Perennial. Stems low and spreading. Leaves oblong or lanceolate, pinnately cleft, the lobes obtuse. Flowers yellow, about $\frac{1}{6}$ in. in diameter. Pods linear oblong, $\frac{1}{3}$–$\frac{1}{2}$ in. long. River bottoms and moist ground W.

3. **R. palustris** Mœnch. Yellow Watercress. Annual or biennial. Stem erect, branched, slightly downy. Leaves irregularly lyrate, the lower petioled, the upper sessile. Flowers small; petals yellow. Pods linear, spreading, longer than the pedicels. In wet places.*

4. **R. Armoracia** Robinson. Horse-Radish. A coarse herb, with large leaves, from stout, long, cylindrical rootstocks filled with a very sharp, biting juice. Basal leaves long-petioled, linear-oblong, obtuse, regularly scalloped; stem-leaves sessile. Racemes in panicles. Pods obovoid, on long, slender pedicels; seeds seldom or never ripening. Probably from Europe; cultivated and often introduced in damp ground.

X. BARBAREA R. Br.

Mostly biennials, somewhat resembling *Radicula*. Flowers yellow. Pod elongated, linear, cylindrical, or somewhat 4-sided. Style short. Seeds in 1 row in each cell, not margined.

1. **B. vulgaris** R. Br. Winter Cress, Yellow Rocket. Smooth, with tufted stems 1–2 ft. high. Lower leaves petioled, pinnately cut, with 1–4 pairs of lateral divisions and a rounded, much longer terminal one; upper leaves nearly or quite sessile. Flowers $\frac{3}{8}$ in. in diameter or less. Pods erect or spreading. Fields and waste ground. Introduced from Europe into the eastern and central states.

XI. DENTARIA L.

Stems naked below, 2–3-leaved above, from a thickish, more or less knotted or interrupted rootstock. Flowers rather large, in early spring. Pod lance-linear, flattish; seeds in 1 row, wingless; seedstalks broad and flat.

1. **D. diphylla** L. Two-Leaved Toothwort, Pepper Root, Crinkle Root. Rootstock long, often branched, toothed, eatable, with a flavor like that of cress or radish. Stem leaves 2, close together, each composed of 3 ovate-diamond-shaped and toothed or crenate leaflets; the basal leaf like the stem leaves. Flowers white. Damp woods.

2. **D. laciniata** Muhl. Crow's-Foot. Rootstock short, necklace-like. Stem leaves 3-parted; basal leaf often absent. Flowers white or rose color. Woods.

XII. CARDAMINE L.

Annual or perennial. Rootstock often scaly or bulb-bearing. Stem erect or ascending, usually smooth. Leaves more or less divided. Flowers in terminal racemes, white or purple. Petals rather large. Stamens 6. Fruit a linear, flattened pod; seeds several, in a single row in each cell.*

1. **C. rhomboidea** DC. Bulbous Cress. Perennial. Root tuberous. Stem simple, erect, smooth, without runners, 9–18 in. tall. Lower leaves long-petioled, ovate, orbicular, or heart-shaped, often angled or toothed; the upper short-petioled or sessile, lanceolate or oblong, toothed or entire. Pedicels $\frac{1}{2}$–1 in. long. Petals white, $\frac{1}{4}$–$\frac{1}{3}$ in. long. Pod erect, linear-lanceolate, tipped by the persistent style; seeds round-oval. Cool, wet places.*

2. **C. pennsylvánica** Muhl. Bitter Cress. Annual. Stem slender, erect, simple, or with a few slender branches, 6–15 in. tall. Leaves mostly in a cluster at the base of the stem, pinnately divided, the terminal lobe roundish, the lateral lobes narrower, somewhat hairy above; stem leaves nearly linear. Flowers small. Petals white, longer than the sepals. Stamens 4. Pods linear, erect on erect pedicels, about 1 in. long; seeds oval. In wet places.*

XIII. ARABIS L.

Annual or perennial herbs, smooth, or with forked or star-shaped hairs. Basal leaves spatulate; stem leaves sessile. Flowers usually white. Petals entire, usually with claws. Pods linear, flattened; seeds often margined or winged.

1. **A. hirsuta** Scop. A rough-hairy, erect, leafy-stemmed biennial, 1–2 ft. high. Leaves simple; stem leaves oblong or lanceolate, entire or toothed, somewhat clasping, often with an arrow-shaped base. Flowers small, greenish-white, the petals somewhat longer than the sepals. Pods and pedicels upright. Style almost wanting. Seeds roundish, somewhat wing-margined. Rocks, N.

2. A. lævigata Poir. A smooth, leafy-stemmed biennial, 1–2 ft. high, covered with a bloom. Stem leaves lance-linear, clasping. Flowers small and whitish, the petals hardly longer than the sepals. Pods 2–3 in. long, flattened, spreading, and recurved; seeds broadly winged. Rocks.

3. A. canadensis L. SICKLE POD. An upright, leafy-stemmed biennial, 2–3 ft. high, simple or slightly branching above, sometimes slightly hairy at the base. Stem leaves sessile, oblong-lanceolate, pointed at both ends, downy; the lower ones toothed. Flowers small, whitish, the petals twice as long as the sepals. Pods scythe-shaped, much flattened, hanging from hairy pedicels; seeds broadly winged. Rocky hillsides.

41. CAPPARIDACEÆ. CAPER FAMILY

Herbs (when growing in cool temperate regions), with bitter or nauseous juice. Leaves alternate, usually palmately compound. Flowers often not actinomorphic, usually bisexual. Sepals 4–8. Petals 4 or wanting. Stamens 6 or more. Ovary and pod 1-celled, with 2 rows of ovules; seeds kidney-shaped.

I. POLANISIA Raf.

Ill-smelling annual plants covered with glandular or clammy hairs. Sepals distinct, spreading. Petals with claws, notched at the tip. Stamens 8–32, of various lengths. Receptacle not lengthened. Pod linear or oblong, rather large, many-seeded.

1. P. graveolens Raf. A very strong-scented, leafy, branching herb, 6–15 in. high. Leaves with 3 oblong leaflets. Flowers small, pinkish and yellowish-white, in the axils of leafy bracts, in terminal racemes. Stamens 8–12, not much longer than the petals. Pod about 2 in. long, slightly stalked. Gravelly banks.

II. CLEOME L.

Mostly annual herbs. Stems branched. Leaves petioled, simple, or with 3–7 entire or serrate leaflets. Flowers in bracted racemes. Sepals 4, often persistent. Petals 4, often long-clawed, nearly equal, entire. Stamens 6, filaments thread-like, usually projecting much, but sometimes 1–3 much shorter than the others, inserted on the short receptacle. Ovary on a short stalk with a small gland at its base. Fruit a slender capsule on an elongated stalk.*

1. **C. serrulata** Pursh. Rocky Mountain Bee Plant, Stinking Clover. A smooth plant 2 ft. or more high. Leaves with 3 leaflets. Flowers pink, showy, in leafy-bracted racemes. Pod oblong to linear, 1-2 in. long. Cultivated as an ornamental plant and also for bees. Common in a wild condition W.

42. RESEDACEÆ. Mignonette Family

Annual or perennial herbs, rarely shrubs. Leaves alternate, simple or pinnately cut. Flowers racemed or spiked, bracted. Calyx 4 7-parted, often not actinomorphic. Petals 4–7, hypogynous, often unequal and cleft or notched. Stamens usually many, borne on a large one-sided hypogynous disk. Ovary of 2–6 carpels, which are more or less united into a single 1-celled, many-seeded, several-lobed or -horned pistil, which opens at the top before the seeds ripen.

RESEDA L.

Annual. Stems diffuse, widely branched. Leaves sessile, entire or lobed, smooth. Flowers in close racemes or spikes. Petals 4–7, toothed or cleft. Stamens 8–30, inserted at one side of the flower. Capsule 3–6-lobed.*

1. **R. odorata** L. Mignonette. Stem widely diffuse, 6–12 in. high, smooth. Leaves wedge-shaped, entire or 3-lobed. Flowers small, greenish-yellow, very fragrant. Petals deeply 7–13-cleft. Often cultivated. From Egypt.*

43. SARRACENIACEÆ. Pitcher Plant Family

Perennial, apparently stemless, marsh herbs. Leaves tubular or trumpet-shaped. Flowers single, nodding, on a naked or bracted scape. Sepals 4–5, colored, persistent. Petals 5, deciduous, or sometimes wanting. Stamens numerous. Pistil compound, 5-celled, many-ovuled; style terminal, nearly as broad as the flower, shield-shaped.*

SARRACENIA L.

Rootstock short, horizontal; scape naked. Leaves trumpet-shaped, with a wing extending nearly to the base and a broad blade at the apex; tube hairy within, with downward-pointing, stiff hairs. Calyx 3-bracted. Petals obovate, drooping or incurved. Style umbrella-shaped, 5-angled; stigmas at the hooked angles of the style on the under surface. Capsule globose, rough. [The tubular leaves usually contain more or less water and dead insects, the latter having been attracted by a honey-like secretion near the opening.]

1. **S. purpurea** L. Sidesaddle Flower. Leaves ascending, curved, broadly winged, purple-veined, 4–8 in. long; blade erect, round-cordate, hairy on the inner side. Scapes 12–18 in. tall; flower deep purple, about 2 in. broad; style yellowish. Mossy swamps.*

44. SAXIFRAGACEÆ. Saxifrage Family

Herbs or shrubs. Leaves alternate or opposite, generally without stipules. Sepals 4 or 5, more or less joined with each other and not usually hypogynous. Petals as many as the sepals and alternate with them. Stamens as many as the petals and alternate with them, or 2–10 times as many. Ovary usually of two carpels, united only at the base or more or less throughout. Fruit generally a 1 2-celled capsule, sometimes a berry; seeds many, with endosperm.

I. SAXIFRAGA L.

Herbs with simple or palmately cut leaves and generally cymose or panicled flowers. Sepals 5, more or less united. Petals 5, entire, inserted on the calyx tube. Stamens 10. Capsule consisting of 2 (sometimes more) ovaries, united at the base, separate and diverging above.

1. **S. pennsylvanica** L. Swamp Saxifrage. Perennial. Leaves 4–8 in. long, oblong-lanceolate and tapering to the base, slightly toothed. Scape 1–2 ft. high, bearing an oblong cluster of small greenish flowers, at length diffusely panicled. Petals greenish-yellow

(rarely crimson), linear-lanceolate, hardly longer than the calyx lobes. Boggy ground.

2. S. virginiensis Michx. EARLY SAXIFRAGE, MAYFLOWER. Perennial. Apparently stemless, with a cluster of spatulate, obovate, or wedge-shaped basal leaves, and a scape 3–9 in. high, which bears a dense cluster of small white flowers, becoming at length a panicled cyme. Petals white, oblong, much longer than the calyx. Rocks and dry hillsides N.

II. TIARELLA L.

Perennial. Flowers white, in racemes. Calyx white, 5-parted, nearly hypogynous. Corolla of 5 very narrow petals, with slender claws, alternating with the calyx lobes. Stamens 10, springing from the calyx tube and extending outside the flower. Styles 2, long and slender; ovary 1-celled, 2-beaked. In fruit one of the carpels grows to be much larger than the other, thus making up the main bulk of the thin, dry pod, which has a few seeds attached near the bottom.

1. T. cordifolia L. FALSE MITERWORT. Stem 5–12 in. high, usually leafless, sometimes with 1 or 2 leaves. Rootstock bearing runners in summer. Leaves heart-shaped, sharply lobed, the lobes with acute or mucronate teeth, somewhat hairy above, downy beneath. Raceme short and simple. Rocky woods, especially N.

III. HEUCHERA L.

Perennials, with a tall scape and roundish, heart-shaped basal leaves. Flowers rather small, greenish or purplish, in a long panicle. Calyx 5-cleft, the tube somewhat perigynous. Petals 5, small, spatulate, inserted with the 5 stamens on the margin of the calyx tube. Capsule 1-celled, 2-beaked, splitting open between the beaks.

1. H. americana L. COMMON ALUM ROOT. Scapes 2–4 ft. high, rather slender, often several from the same root, hairy and glandular. Basal leaves large and long-petioled, abundant, somewhat 7-lobed. Flowers whitish with a tinge of purple, in a loose panicle. Stamens projecting considerably outside the flower, their anthers of a bright terra cotta color. The root is very astringent and is somewhat used as a home remedy. Shaded banks, fence rows, and thickets; common W.

IV. MITELLA L.

Delicate perennial herbs. Flowers small, pretty, in a simple raceme or spike. Calyx 5-cleft, slightly perigynous. Petals 5, cut-fringed, inserted on the throat of the calyx tube. Stamens 5 or 10, not projecting from the calyx tube. Styles 2, very short. Ovary and pod 2-beaked, globular, 1-celled.

1. **M. diphylla** L. TWO-LEAVED BISHOP'S CAP, FRINGE CUP, FAIRY CUP. Stemless, with long-petioled, roundish-cordate root leaves, and a scape about 1 ft. high, bearing 2 opposite, nearly sessile leaves. Flowers many, racemed, white. Woods.

V. PHILADELPHUS L.

Shrubs. Leaves simple, opposite, 3–5-ribbed, petioled, without stipules. Flowers solitary or in cymes, large, white. Calyx tube top-shaped, the epigynous limb 4–5-parted, persistent. Petals 4–5, rounded or obovate. Stamens 20–40, shorter than the petals. Ovary 3–5-celled, many-seeded; styles 3–5, more or less united.*

1. **P. grandiflorus** Willd. LARGE-FLOWERED SYRINGA. Shrub, 6–10 ft. high; branches downy. Leaves ovate or ovate-oblong, taper-pointed, sharply serrate, downy, 3-ribbed. Flowers solitary or 2–3 together, white, 1½–2 in. broad, not fragrant. Calyx lobes ovate, taper-pointed, about twice as long as the tube. On low ground S., and cultivated.*

2. **P. coronarius** L. GARDEN SYRINGA. Shrub, 8–10 ft. high. Leaves oval or ovate, obtuse at the base, acute at the apex, remotely toothed, smooth above, downy beneath. Flowers in terminal racemes, creamy white, 1–1½ in. wide, very fragrant. Calyx lobes ovate, acute, longer than the tube. Common in cultivation. From southern Europe.*

VI. DEUTZIA Thunb.

Shrubs with simple, opposite leaves, without stipules. Flowers all bisexual and alike, racemed or panicled, showy. Calyx lobes 5. Petals 5. Stamens 10, 5 long and 5 short; filaments flat and 3-pronged, the middle prong bearing an anther. Styles 3–5, slender. Pod 3–5-celled.

1. **D. gracilis** Sieb. & Zucc. About 2 ft. high, loosely spreading. Leaves ovate-lanceolate, sharply serrate, smooth. Flowers white, very numerous. Cultivated from Japan, often in greenhouses.

VII. RIBES L.

Shrubs. Leaves palmately veined and lobed, sometimes with stipules. Calyx tube egg-shaped, its 5 epigynous lobes usually colored like the petals. Petals 5, small, generally inserted on the throat of the calyx tube. Stamens 5, inserted with the petals. Styles 2; ovary 1-celled, with 2 placentæ on its walls, becoming in fruit a pulpy (usually eatable) berry.

1. **R. Cynosbati** L. PRICKLY WILD GOOSEBERRY. Spines in pairs. Leaves long-petioled, downy, heart-shaped, cut-dentate. The single style and the stamens not projecting from the calyx tube. Berries generally prickly, brownish-purple, pleasant-flavored.

2. **R. gracile** Michx. SLENDER GOOSEBERRY. Spines slender, solitary, or in pairs or threes. Leaves with slender petioles, somewhat downy when young, round, the base truncate or obtuse, 3–5-lobed, the divisions obtuse and toothed. Flowers often in threes, white or greenish, drooping. Calyx lobes longer than the tube; stamens decidedly projecting from the tube. Berries smooth, reddish-purple. Dry or rocky soil W.

3. **R. rotundifolium** Michx. SMOOTH WILD GOOSEBERRY. Spines few and short, prickles few or absent. Leaves roundish, lobed, with the lobes crenate-dentate, often downy. Peduncles slender; flowers inconspicuous. Calyx lobes reflexed. Styles and stamens projecting decidedly from the calyx tube. Berries smooth.

4. **R. oxyacanthoides** L. NORTHERN GOOSEBERRY. Spines usually solitary, often numerous. Leaves petioled, their lower surfaces and petioles commonly downy. Flowers 1–3 together, on short pedicels, greenish-purple or white. Berry $\frac{1}{3}$–$\frac{1}{2}$ in. in diameter, smooth, reddish-purple. Low grounds and damp woods N.

5. **R. americanum** Mill. WILD BLACK CURRANT. Branches thornless, erect. Leaves resinous-dotted, somewhat heart-shaped, 3–5-lobed, toothed. Flowers large, whitish. Calyx tubular-bell-shaped, smooth. Fruit round-ovoid, black, smooth. In woods.

6. **R. vulgare** Lam. RED CURRANT. Stems more or less reclining. Leaves somewhat heart-shaped, obtusely 3–5-lobed. Racemes drooping. Limb of the calyx wheel-shaped. Berries acid, eatable, red or light amber-colored. Cultivated from Europe; also somewhat naturalized.

7. **R. odoratum** Wendland. GOLDEN CURRANT, FLOWERING C., MISSOURI C., CLOVE CURRANT. A much taller shrub than the common red currant. Leaves 3-lobed, toothed. Racemes short and loose. Tube of the yellow calyx much longer than its limb. Flowers very fragrant. Fruit brownish-black, barely eatable.

45. PLATANACEÆ. Sycamore Family

Trees, with simple, alternate, petioled leaves, with stipules; the bases of the petioles covering the buds. Flowers monœcious, in axillary, long-peduncled, globose heads. Calyx and corolla very inconspicuous, each consisting of 3–8 minute scales, or wanting. Stamens as many as the sepals and opposite them. Pistils several, inversely conical, hairy at the base; styles long. Capsules 1-seeded.*

PLATANUS L.

Characters of the family.

1. P. occidentalis L. Sycamore, Buttonwood. A large tree, bark light-colored, smooth, peeling off in large, thin plates. Leaves large, round-heart-shaped, angularly lobed and toothed, densely white-woolly when young, becoming smooth with age; stipules large, toothed. Fruit in a globular, drooping head, which remains on the tree through the winter, dropping the seeds very slowly. Common on river banks and in swampy woods.*

46. ROSACEÆ. Rose Family

Herbs, shrubs, or trees. Leaves alternate or rarely opposite, simple or compound, with stipules. Calyx 5-lobed. Petals 5, rarely wanting, inserted with the stamens on the edge of a disk that lines the calyx tube. Stamens many, rarely 1 or few. Carpels 1 or more, distinct or united, superior or inferior. Fruit a pome, a drupe or group of drupes, or 1–several akenes or follicles, rarely a berry or capsule. The relation of the parts of the flower to each other and to the receptacle is shown in Fig. 19.

A

Ripe carpels not inclosed within the calyx tube.

1. Fruit dry.
   - (*a*) Carpels 1–5, inflated. Physocarpus, I
   - (*b*) Pods 5–8, not inflated, 2–several-seeded. Spiræa, II

(*c*) Carpels 5–15 (usually 10), 1-seeded. Filipendula, X

(*d*) Akenes 2–6, styles not lengthening after flowering. Waldsteinia, VIII

(*e*) Akenes many, on a dry receptacle. Styles not lengthening. Potentilla, IX

(*f*) Akenes many, on a dry receptacle. Styles lengthening after flowering, forming tails to the akenes. Geum., XI

2. Fruit fleshy.

(*a*) Akenes several–many, becoming little drupes. Rubus, XII

(*b*) Akenes many, dry on ripening, on a fleshy, eatable receptacle. Fragaria, VII

(*c*) Pistil solitary, becoming a drupe Prunus, XIV

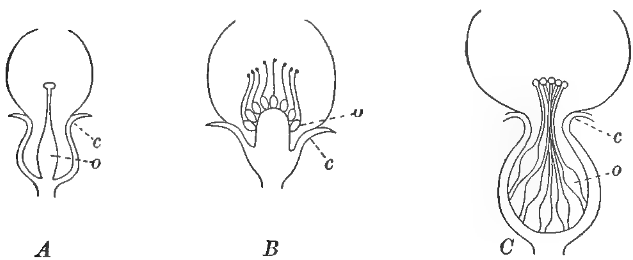


FIG. 19. Pistils in the Rose Family

A, *Prunus*-type; *B*, *Potentilla*-type; *C*, *Rosa*-type. *c*, calyx; *o*, ovary

B

Ripe carpels inclosed within the calyx tube.

1. Fruit a pome.

(*a*) Carpels more than 2-seeded; seeds covered with a mucilaginous pulp. Fruit 5-celled. Cydonia, III

(*b*) Carpels 2-seeded (except in some cultivated varieties); seeds without pulp. Fruit 5-celled. Pyrus, IV

(*c*) Carpels 2-seeded; fruit 10-celled. Amelanchier, V

2. Fruit not evidently a pome, or not at all so.
   (*a*) Trees or shrubs. Fruit with a stone usually of 2–5 bony 1-seeded carpels united. Cratægus, VI
   (*b*) Shrubs. Fruit with many akenes borne on the interior of a fleshy calyx tube. Rosa, XIII

I. PHYSOCARPUS Maxim. (OPULASTER)

Shrubs. Leaves simple, palmately veined and lobed, petioled. Flowers white, in terminal corymbs. Calyx spreading, 5-lobed. Petals 5. Stamens numerous. Pistils 1–5, short-stalked; stigma terminal; ovaries becoming inflated at maturity, 2–4-seeded, splitting open.*

1. P. opulifolius Maxim. NINE-BARK. A spreading shrub, 3–6 ft. high, the old bark separating into thin strips. Leaves petioled, broadly ovate or rounded, often heart-shaped, 3-lobed, the lobes doubly crenate-serrate; stipules deciduous. Corymbs terminal, peduncled, nearly globose, downy, many-flowered. Follicles 3–5, much longer than the calyx, smooth and shining, obliquely tipped by the persistent style. Banks of streams.*

II. SPIRÆA L.

Shrubs with simple leaves. Flowers perfect, in terminal or axillary racemes or panicles. Calyx 5-cleft, persistent. Petals 5. Stamens numerous. Pistils usually 5, free from the calyx and alternate with its lobes. Follicles not inflated, 2-several-seeded.*

1. S. salicifolia L. WILLOW-LEAVED SPIRÆA. Shrubs 2–5 ft. high, branches smooth. Leaves lanceolate to oblong-ovate, smooth or nearly so, sharply serrate, base usually wedge-shaped, pale beneath; stipules deciduous. Flowers white or pink, panicle dense-flowered; follicles smooth. On low ground.*

2. S. cantoniensis Lour. BRIDAL WREATH. Shrubs 2–4 ft. tall; branches long, slender, and spreading. Leaves lanceolate, serrate, sometimes 3-lobed or pinnatifid, with a bloom beneath. Flowers white or pinkish, in axillary racemes or corymbs, often forming long wreaths. Follicles smooth. Cultivated from Europe.

3. S. tomentosa L. HARDHACK. Erect shrubs. Stems densely downy, usually simple. Leaves simple, ovate or oblong, serrate, densely rusty-downy below, smooth and dark green above. Flowers small, pink or purple, in a close panicle. Follicles 5, densely downy, several-seeded. On low ground S., and along fence rows and in pastures N., where it is a troublesome weed.*

III. CYDONIA L.

Trees or shrubs. Leaves simple, toothed or lobed, stipules deciduous. Flowers usually solitary, white or pink. Calyx tube urn-shaped, 5-lobed, its epigynous lobes acute, spreading, persistent. Petals 5. Stamens numerous, inserted with the petals on the calyx tube. Styles 2–5, mostly 5, united at the base; ovary 5-celled, seeds many in each cell. Fruit a pome, globose, usually depressed or hollowed at the extremities; flesh without hard grains.*

1. C. vulgaris Pers. Quince. Shrub 6–12 ft. high. Leaves oblong-ovate, acute at the apex, obtuse at the base, entire, downy below. Flowers large, white or pink. Fruit ovoid, downy. Cultivated.*

2. C. japonica Pers. Japan Quince. A widely branching shrub, 3–6 ft. high; branches with numerous straight spines. Leaves ovate-lanceolate, acute at each end, smooth and shining, serrulate; stipules conspicuous, kidney-shaped. Flowers in nearly sessile axillary clusters, bright scarlet. Fruit globose. Common in cultivation.*

IV. PYRUS L.

Trees. Leaves simple, stipules small, deciduous. Flowers in cymes, large, white or pink. Calyx urn-shaped, 5-cleft, its epigynous lobes acute. Petals rounded, short-clawed. Stamens numerous, borne with the petals on the calyx tube. Styles 5, distinct or slightly united at the base. Fruit a pome, with about 2 seeds in each carpel.*

B. Fl. species 2–5 (*Malus*); species 6 (*Aronia*); species 7, 8 (*Sorbus*).

1. P. communis L. Pear. A tree, often very large; head usually pyramidal, branches often thorny. Leaves thick and leathery, ovate or oval, acute, finely serrate or entire, downy when young, becoming smooth with age; petioles slender. Cymes few–several-flowered, terminal, and at the ends of "fruit spurs" grown the previous season. Flowers white. Styles not united. Fruit obovoid, with hard gritty grains near the core. A European and Asiatic tree common in cultivation.*

2. P. angustifolia Ait. Narrow-Leaved Crab Apple. A small tree, with smooth, light gray bark. Leaves lanceolate or oblong, serrate, downy when young, acute at the base, short-petioled. Corymbs few-flowered. Flowers pink, fragrant, about 1 in. broad. Styles smooth, distinct. Fruit nearly globose, about ¾ in. in diameter, very sour. In open woods, Pennsylvania, West, and South.*

3. P. coronaria L. American Crab Apple. A small tree, with smooth bark. Leaves triangular or oval-lanceolate, acutish or rounded or a little heart-shaped at the base, cut-serrate and often somewhat 3-lobed, slender-petioled, soon smooth. Flowers large, few in a cluster, pale rose color, very sweet-scented. Fruit bright green, turning yellowish, sometimes 1½ in. in diameter, flattened at right angles to the pedicels, very fragrant. Glades, western New York, West, and South.

4. P. ioensis Bailey. Western Crab Apple. A small tree, much like *P. coronaria* but with the leaves white-downy beneath, ovate-lanceolate and narrowed at the base. Fruit dull green with light dots, about 1 in. in diameter. Thickets W.

5. P. Malus L. Apple. A tree with a rounded top and dark-colored bark. Leaves oval or ovate, obtuse or pointed, dentate or nearly entire, rounded at the base, smooth above, downy beneath. Cymes few–many-flowered. Flowers large, white or pink. Calyx downy. Fruit depressed-globose to ovoid, hollowed at the base and usually at the apex. Cultivated from Europe and often running wild in old pastures, etc., E.*

6. P. arbutifolia L. f. Chokeberry, Choke Pear, Dogberry. A shrub, 5–8 ft. high. Leaves oblong or oblanceolate, finely serrate, downy beneath, short-petioled. Flowers in a downy compound cyme, small, white or reddish. Fruit pear-shaped or nearly globular, not larger than a currant, very dark purple, dry and puckery. There is also a smooth-leaved variety with black fruit. Swamps and damp thickets, especially N.E.

7. P. americana DC. American Mountain Ash. A tall shrub or small tree. Leaves odd-pinnate. Leaflets oblong-lanceolate, taper-pointed, sharply serrate, smooth, bright green. Flowers small, white, in large flat, compound cymes. Fruit bright scarlet, not larger than currants. Common N. and often cultivated.

8. P. Aucuparia Ehrh. European Mountain Ash or Rowan Tree. Larger than No. 7. Leaflets paler, downy beneath. Fruit larger, about ½ in. in diameter. Cultivated from Europe.

V. AMELANCHIER Medic.

Shrubs or small trees, with smooth gray bark. Leaves simple, sharply serrate, petioled. Flowers white, in racemes.

Calyx tube 5-cleft, its lobes epigynous. Petals oblong. Styles 5, united below; ovary 5-celled, 2 ovules in each cell, often only 1 maturing. Fruit small, berry-like.*

1. **A. canadensis** Medic. SERVICE BERRY, JUNEBERRY, SHAD BUSH, SUGAR PLUM, SUGAR PEAR, WILD PEAR. A small tree, branches downy when young, soon becoming smooth. Leaves ovate to elliptical, finely and sharply serrate, acute at the apex, usually obtuse or cordate at the base. Racemes slender, many-flowered, appearing before or with the leaves. Flowers showy. Petals 4 or 5 times the length of the smooth calyx lobes. Fruit globose, dark red, edible. In rich woods. Extremely variable in height and in shape of leaves.*

2. **A. spicata** K. Koch. ROUND-LEAVED JUNEBERRY. Much like *A. canadensis*, but with the leaves broadly oval, ovate, or almost orbicular, and usually rounded at both ends. Woods and thickets, especially N.

VI. CRATÆGUS L.

Shrubs or small trees, mostly with numerous strong spines, wood very hard. Leaves serrate, lobed or deeply incised, petioled. Flowers white or pink, in terminal corymbs or sometimes solitary. Calyx tube urn-shaped, 5-cleft, the limb persistent. Petals round. Stamens few or many. Styles 1–5, distinct; ovules 1 in each cell. Fruit a small pome with bony carpels.* [The species are hard to distinguish and are not very perfectly defined. Probably more than 60 species occur within the limits of this flora.]

VII. FRAGARIA L.

Perennial scape-bearing herbs, with runners. Leaves with 3 leaflets; stipules united to the petiole. Flowers (of American species) white. Calyx hypogynous, 5-parted, 5-bracted, persistent. Petals 5. Stamens many. Carpels many, on a convex receptacle. Akenes of the ripe strawberry many, very small, more or less imbedded in the large, sweet, pulpy receptacle.

1. **F. virginiana** Duchesne. WILD STRAWBERRY. Leaflets thick, oval to obovate, coarsely serrate, somewhat hairy. Scape usually shorter than the petioles, few-flowered. Fruit ovoid, akenes imbedded in deep pits. Common.*

2. F. vesca L. European Strawberry. Leaflets ovate or broadly oval, dentate above, wedge-shaped below, slightly hairy. Scape usually longer than the petioles. Fruit globular or oval, akenes adherent to the nearly even surface of the receptacle. Common in cultivation. Many of the cultivated varieties of strawberry are hybrids between the two described above. The following variety is by some regarded as distinct.*

Var. **americana** Porter. American Wood Strawberry. Slender, smooth or silky-downy. Leaflets very thin, sharply cut-toothed, downy beneath with close-lying silvery hairs, the down of the scapes, the pedicels, and sometimes of the leafstalks also, usually close-lying. Calyx lobes reflexed in fruit. Rocky woods.

VIII. WALDSTEINIA Willd.

Stemless perennial herbs. Leaves 3–5-lobed or -divided. Flowers several, rather small, yellow, on a bracted scape. Calyx tube top-shaped; the limb spreading, with sometimes little bracts alternating with the lobes. Petals 5. Stamens many. Style 2–6. Akenes few, on a dry receptacle.

1. W. fragarioides Tratt. Barren Strawberry. A low herb with much the appearance of a strawberry plant. Leaflets 3, broadly wedge-shaped, crenate-dentate. Scapes many-flowered; the flowers rather pretty. Wooded hillsides.

IX. POTENTILLA L.

Perennial herbs, rarely shrubs. Leaves compound; stipules united to the petiole. Flowers white or yellow, rarely red; solitary or in cymes. Calyx hypogynous, 5-cleft, with 5 little bracts alternating with its lobes. Petals 5. Stamens many. Carpels usually many, on a dry convex or concave receptacle; styles falling off from the akenes as they mature.

B. Fl. species 5 (*Argentina*).

1. P. arguta Pursh. Upright Cinquefoil. An erect, stout, hairy plant, 1–4 ft. high. Basal leaves long-petioled, pinnate. Stem leaves few, each of 3–7 leaflets, the latter broadly ovate and cut-toothed or serrate, downy underneath. Flowers large, in dense terminal clusters; the petals whitish or cream color. Rocky hills.

2. P. monspeliensis L. Rough Cinquefoil. Annual or biennial. Stem rough-hairy, erect and stout, 6–30 in. high. Leaves of 3 leaflets, the lower petioled, the upper stem leaves sessile or nearly so, leaflets cut-serrate. Flowers small, in a close, leafy cyme. Styles glandular-thickened at the base. In dry soil.

3. P. rivalis Nutt., var. **millegrana**. DIFFUSE CINQUEFOIL. Annual. Stems decumbent or ascending, commonly diffusely branched, 1¼–3 ft. high, clothed with long, soft hairs or nearly smooth. Leaves all but the uppermost of 3 leaflets and petioled; leaflets oblong, wedge-shaped, thin, deeply serrate. Flowers yellow, in loose, leafy cymes. Style somewhat thickened below. In damp soil W.

4. P. argentea L. SILVERY CINQUEFOIL. Stems prostrate or ascending and branching, woolly. Leaflets oblong, wedge-shaped, those of the upper leaves very narrow, with a few large, deeply cut teeth, smooth and green above, silvery beneath, with a dense coat of white wool. Flowers small and somewhat clustered, yellow. Dry fields and roadsides.

5. P. Anserina L. SILVERWEED. Stems spreading by slender runners, with many joints, silky-hairy. Leaves all basal, pinnate; leaflets 7–21, serrate, oblanceolate or obovate, nearly smooth above, white and silky-downy beneath. Flowers yellow, ½–1 in. in diameter. Style thread-like. River banks, brackish marshes, and borders of lakes.

6. P. canadensis L. COMMON CINQUEFOIL. Stems slender, procumbent, silky-hairy, sending out long runners. Leaflets obovate, wedge-shaped, appearing like 5 from the divisions of the 2 lateral ones. Peduncles 1-flowered in the axils of the leaves. Flowers yellow. Common in dry pastures and a troublesome weed.

X. FILIPENDULA Hill. (ULMARIA)

Tall perennial herbs. Leaves pinnately divided, with stipules. Flowers small, bisexual, in panicled cymes. Calyx 5-lobed. Petals 5, with claws. Stamens many, hypogynous, borne on a flat or slightly hollowed receptacle. Pistils 5–15, distinct. Carpels when ripe 1–2-seeded, looking like follicles but not splitting open.

1. F. rubra Hill. QUEEN OF THE PRAIRIE. Smooth, branching, 2–8 ft. high. Leaves very large, of 3–7 pinnately arranged leaflets, often with smaller ones between, the lobes cut or toothed; terminal leaflet much larger, 7–9-parted. Flowers showy, pink, fragrant, about ⅓ in. in diameter. Meadows and prairies, especially in moist soil, sometimes cultivated.

2. F. Ulmaria Maxim. MEADOWSWEET. Stem 1–3 ft. high. Leaves lyrate, interruptedly pinnate, white-downy beneath. Flowers yellowish-white, small, fragrant, in a dense compound cyme. Pods spirally twisted. Cultivated from Europe and sometimes escaping.

XI. GEUM L.

Erect perennial herbs. Basal leaves crowded, pinnate, with a very large terminal leaflet. Flowers and fruit much as in *Potentilla*, but the akenes tailed with the remains of the styles. B. Fl. species 5 (*Sieversia*).

1. G. canadense Jacq. White Avens. Stem erect, branching above, smooth or finely downy, 18–24 in. high. Basal leaves pinnate, or the earliest simple and rounded, long-petioled, serrate or dentate; terminal lobe larger than the lateral lobes; stem leaves short-petioled, 2–5-lobed or -parted. Flowers on slender peduncles. Petals white, not longer than the sepals. Styles jointed near the middle, the lower portion persistent and hooked. Ovaries and receptacle hairy; head of fruit globose. Rich woods.*

2. G. virginianum L. Stem 2–3 ft. high, stout and bristly-hairy. Lower leaves and basal leaves pinnate, varying greatly; upper leaves mostly of 3 leaflets or 3-parted. Petals white or pale yellow, small, shorter than the calyx lobes. Heads of fruit large, on stout, hairy peduncles; the receptacle nearly or quite smooth. Borders of woods and damp thickets.

3. G. macrophyllum Willd. Large-Leaved Avens. Stem stout, erect, bristly-hairy, 1–3 ft. high. Basal leaves lyrate-pinnate, the terminal portion much the largest, kidney-shaped or heart-shaped; lateral leaflets 3–6, with smaller ones between. Flowers terminal, yellow. Style $\frac{1}{4}$–$\frac{1}{3}$ in. long, downy below. In low grounds.

4. G. rivale L. Water Avens, Purple Avens, Chocolate Root. Stem $1\frac{1}{2}$–2 ft. high, somewhat downy or hairy, simple or nearly so. Basal leaves lyrate and somewhat pinnate, with the divisions irregular; stem leaves few, of 3 leaflets or 3-lobed. Flowers rather large. Petals purplish-yellow, as long as the brownish-purple calyx lobes. Styles long, purplish; stigmas thread-like, feathered with soft hairs, especially in fruit. Wet meadows.

5. G. triflorum Pursh. Long-Plumed Purple Avens. Softly downy, scapes 6–18 in. high. Basal leaves petioled, tufted, pinnate; the larger leaflets obovate or oval, cut-toothed, with many smaller ones between. Flowers 3–8, light purple. Styles $1\frac{1}{2}$–2 in. long. In dry or rocky soil.

XII. RUBUS L.

Mostly prickly shrubs, producing runners. Leaves alternate, simple or compound; stipules united to the petiole. Flowers in terminal and axillary clusters, rarely solitary, white (in one American species (No. 3) purple rose color). Calyx hypogynous, with a broad tube; its lobes 5, persistent. Petals 5. Stamens many. Carpels many, distinct, on a convex receptacle. Fruit a cluster of little 1-seeded drupes on a dry or somewhat juicy receptacle.

A. Raspberries

Grains of the fruit, when ripe, usually falling off from the receptacle and leaving the latter with the calyx.

1. **R. idæus** L., var. **aculeatissimus.** Red Raspberry. Stems widely branching, biennial, not rooting at the tips, armed with weak bristles and with a few hooked prickles. Leaves petioled, of 3–5 ovate leaflets which are sharply serrate and sometimes lobed, downy beneath. Flowers in terminal and axillary racemes and panicles, pedicels drooping. Fruit hemispherical or conical, red, separating easily from the receptacle. Common on mountains and burned clearings, Iowa and N., and widely cultivated.*

2. **R. occidentalis** L. Black Raspberry. Stems long and slender, often recurved and rooting at the tips, armed with weak, hooked prickles. Leaves petioled, 3–5 ovate leaflets, coarsely serrate, white-downy below. Flowers white, in compact terminal corymbs. Pedicels erect or ascending. Fruit black, hemispherical, separating easily from the receptacle. Common on borders of woods, Missouri and N., widely cultivated.*

3. **R. odoratus** L. Flowering Raspberry (often wrongly called Mulberry). Stems shrubby, rather stout, 3–5 ft. high, not prickly; the young shoots, peduncles, and calyx covered with sticky glandular hairs. Leaves large, simple, 3–5-lobed. Flowers showy, rose-purple, 1–2 in. in diameter, on many-flowered peduncles. Fruit red, flattish, eatable. Rather common E. and N., and often cultivated.

4. **R. triflorus** Richards. Dwarf Raspberry (also wrongly known as Mulberry). A slender, trailing plant, almost entirely herbaceous, not prickly but sometimes bristly. Leaves compound, usually of 3 but sometimes of 5 thin, ovate-lanceolate, frequently unsymmetrical leaflets, which are coarsely doubly serrate and often cleft or lobed, with a shining upper surface. Flowers small, on 1–3-flowered peduncles. Fruit usually few-grained, rather dark red, eatable, the grains adhering somewhat to the receptacle. Common, especially N., in hilly woods, often forming a dense carpet in the partial shade of pines.

B. Blackberries

Grains of the ripe fruit falling from the calyx along with the soft, eatable receptacle.

5. **R. allegheniensis** Porter. High Blackberry. Stem shrubby, erect or bending, 3–7 ft. high, glandular-downy above and with stout,

straightish prickles below. Leaves petioled, of 3–7 ovate leaflets which are acute, irregularly serrate, soft-hairy beneath. Flowers racemed, the lower ones leafy-bracted. Petals white, obovate, much longer than the taper-pointed sepals. Fruit long, of small drupelets. Common in thickets.*

6. R. cuneifolius Pursh. SAND BLACKBERRY. Stem shrubby, erect or diffuse, 2–3 ft. high; prickles straight or recurved. Leaves petioled, 3–5-foliate; leaflets obovate, serrate towards the apex, wedge-shaped towards the base, rough above, white downy-woolly beneath. Racemes mainly terminal, few-flowered. Petals white, longer than the sepals. Fruit ovoid, black, smaller than the preceding. Common in old fields.*

7. R. hispidus L. RUNNING SWAMP BLACKBERRY. Stem trailing or prostrate, often several feet in length, armed with recurved prickles. Leaves petioled, mostly of 3 leaflets; leaflets obovate, obtuse, thick, dark green and shining above. Flowering branches commonly erect, few-flowered, flowers white. Fruit small, reddish, turning nearly black. In swamps and low ground.

8. R. villosus Ait. LOW BLACKBERRY, DEWBERRY. Stems shrubby, trailing widely, 3–10 ft. long, somewhat prickly. Leaflets usually 3, but sometimes 5 or 7, ovate, acute, sharply (and doubly) cut-serrate, thin. Racemes upright on the short branches, 1–3-flowered. Fruit roundish, of fewer and larger grains than No. 5, very sweet when fully ripe. Common N., in stony or gravelly fields.

XIII. ROSA L.

Erect running or climbing prickly shrubs. Leaves pinnate, leaflets serrate, stipules united to the petiole. Calyx tube urn-shaped, with a rather narrow mouth. Petals (in single roses) 5. Stamens many, inserted around the inside of the mouth of the calyx tube. Ovaries many, hairy, ripening into bony akenes, inclosed in the rather fleshy and sometimes eatable calyx tube.

1. R. pratincola Greene. Stems densely prickly, 1–2 ft. high. Stipules narrow, usually with glandular teeth or a fringe of glandular hairs toward the tip; leaflets 7–11, varying from elliptical to nearly obovate, obtuse at the tip, narrowed at the base, simply toothed or serrate, rather firm and distinctly veined. Flowers usually in corymbs; sepals lanceolate, taper-pointed. Fruit globose, smooth. Prairies, especially W.

2. R. blanda Ait. EARLY WILD ROSE. Stems 1–3 ft. high, usually without prickles; stipules broad. Flowers generally large, corymbed or solitary; sepals after flowering closing over the mouth of the calyx tube and persistent. Rocks and rocky shores.

3. R. Woodsii Lindl. Stems 3–36 in. high, with slender spines which are often wanting above. Stipules rather broad, entire; leaflets usually 5–7, varying from obovate to lanceolate, rather obtuse at the apex, narrowed at the base, somewhat serrate. Flowers corymbed or solitary. Sepals erect on the globose or somewhat ovoid fruit. Prairies W.

4. R. rubiginosa L. SWEETBRIER. Stem erect or curving, armed with stout recurved prickles. Leaves with 5–7 leaflets, the latter broadly oval, coarsely serrate, glandular-bristly beneath, aromatic. Flowers white or pink. Sepals widely spreading, deciduous. Fruit obovate, slightly bristly. Common in cultivation and sometimes wild.*

5. R. carolina L. SWAMP ROSE. Stems 4–8 ft. high, with stout and generally recurved prickles. Stipules long and narrow; leaflets commonly downy beneath, finely serrate. Flowers several in a corymb, bright rose color. Sepals spreading and falling off after flowering. Damp woods and borders of swamps.

6. R. virginiana Mill. DWARF WILD ROSE. Stems varying in height from less than a foot to 6 ft., with stout, somewhat hooked prickles. Stipules rather broad; leaflets small, thickish and glossy above, coarsely toothed toward the tip. Flowers corymbed or solitary, pale rose color. Sepals spreading and falling off after flowering. Moist ground and swamps.

7. R. humilis Marsh. PASTURE ROSE. Stem erect, branched, usually armed with stout stipular prickles and with bristles, but sometimes nearly smooth, 1–3 ft. tall. Leaves mostly of 5 leaflets; stipules entire; leaflets oblong-lanceolate or oval, shining above, pale beneath, sharply serrate. Flowers solitary or 2–3 together, 2–3 in. broad, pink. Peduncles and calyx glandular-downy. Sepals leaf-like, spreading, finally deciduous. Styles distinct. Fruit globose, bristly-hairy. On dry soil; our most common wild rose. S.*

XIV. PRUNUS L.

Trees or shrubs. Leaves simple, with stipules, which are often small or fall off early. Calyx with a bell-shaped or urn-shaped tube and 5-lobed spreading limb, falling off after flowering. Petals 5; stamens 3–5 times as numerous, or indefinite, inserted on the throat of the calyx tube. Pistil 1, long-styled, with 2 ovules, ripening into a single drupe.

B. Fl. species 8 (*Amygdalus*).

A. *Stone more or less spherical; fruit smooth when ripe. Branches not spiny. (Cherries.)*

1. P. serotina Ehrh. WILD BLACK CHERRY. Often becoming a large tree; bark on old trees rough, nearly black. Leaves rather thick, oval to lanceolate-ovate, acute or taper-pointed at the apex, finely serrate with calloused teeth, smooth above, downy on the veins beneath. Racemes terminal, long and spreading. Flowers white. Fruit globose, about $\frac{1}{4}$ in. in diameter, purplish-black. In rich woods. Wood much used in cabinet-making.*

2. P. virginiana L. CHOKECHERRY. A shrub or small tree, 5–20 ft. high. Leaves thin, oval or obovate, pale, pointed, sharply serrate. Flowers small, white, in short racemes. Fruit bright red, turning at length to dark crimson, very puckery until fully ripe. River banks and thickets.

3. P. pennsylvanica L. f. WILD RED CHERRY. A tree 20–30 ft. high, with light, reddish-brown bark. Leaves oval or oblong-lanceolate, pointed, finely serrate, with both sides green, smooth and shining. Flowers long-pediceled, many in a cluster, the clusters lateral, leafless. Fruit globose, very small, light red, with thin sour pulp and globular stone. In rocky woods.

4. P. Besseyi Bailey. WESTERN SAND CHERRY. A shrub 1–4 ft. high, often with spreading and prostrate branches. Leaves usually elliptic or oblong-elliptic, with appressed teeth. Flowers sessile in lateral umbels, $\frac{1}{3}$ in. to nearly $\frac{1}{2}$ in. in diameter, opening with the leaves. Fruit black, mottled, or yellowish, $\frac{1}{2}$–$\frac{2}{3}$ in. in diameter, bitter and astringent. Prairies W.

5. P. Cerasus L. CHERRY. Often becoming a large tree. Leaves oval or ovate, acute or taper-pointed at the apex, rounded at the base, irregularly serrate-dentate, smooth on both sides, resinous when young. Flowers in lateral umbels, white; pedicels long and slender. Fruit globose, red or black. Cultivated from Europe. This is the species from which most of our sour cultivated varieties have been developed.*

B. *Stone oval, compressed: fruit smooth when ripe. Branches often spiny. (Plums.)*

6. P. angustifolia Marsh. CHICKASAW PLUM. A small tree with spiny branches. Leaves lanceolate or oblong-lanceolate, acute at the apex, usually obtuse at the base, finely and sharply serrate, rather thin, smooth. Flowers in lateral, sessile umbels, pedicels short. Calyx smooth. Fruit yellowish-red, subglobose, skin thin, stone only slightly compressed. In old fields S.*

7. P. americana Marsh. WILD PLUM. A small tree, bark thick and rough, branches spiny. Leaves ovate or obovate, acuminate at the apex, rounded or cordate at the base, sharply serrate, rather thick, downy beneath; petioles glandular. Flowers in lateral, sessile umbels, appearing with or before the leaves; pedicels $\frac{1}{2}$–$\frac{3}{4}$ in. long, flowers $\frac{1}{2}$–$\frac{3}{4}$ in. in diameter. Calyx downy within. Fruit globose, red or yellow, $\frac{1}{2}$–1 in. in diameter. Common in woods.*

C. *Stone deeply furrowed and pitted; fruit downy when ripe. Branches not spiny.* (*Peaches and almonds.*)

8. P. persica Stokes. PEACH. A tree with a rounded top; bark nearly smooth. Leaves lanceolate, taper-pointed, finely serrate, smooth on both sides; petioles usually bearing 2 or 4 crescent-shaped or cup-shaped glands. Flowers pink, scaly-bracted. Fruit ovoid, with a seam along one side. Often escaped from cultivation.*

47. LEGUMINOSÆ. PULSE FAMILY

Herbs, shrubs, or trees. Leaves alternate, usually compound (either pinnately or palmately), with stipules, the leaflets mostly entire. Calyx of 5 sepals, which are more or less united, often somewhat zygomorphic. Corolla of 5 petals,

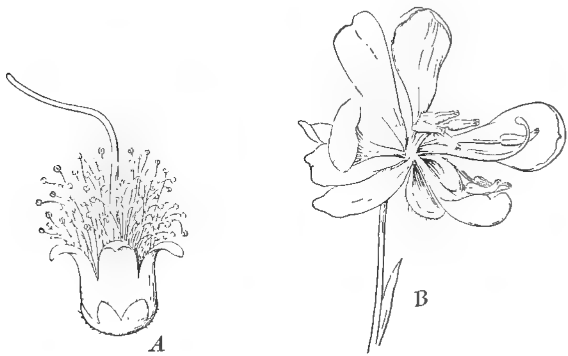


FIG. 20. Pulse Family

A, actinomorphic corolla (*Acacia cinerascens*); *B*, zygomorphic corolla (*Cassia marilandica*). (After Schnizlein)

often papilionaceous (Fig. 21) or somewhat actinomorphic, in No. XVI much reduced. Stamens diadelphous (Fig. 22), monadelphous, or distinct. Ovary simple, superior. Fruit usually a 1-celled pod (Fig. 22). Seeds one or several, without endosperm. A large and very important family, containing about 8000 species.

A

Flower actinomorphic, small. Stamens hypogynous. Leaves twice pinnate.

Petals not united to each other. Stamens 5 or 10. Pod smooth. Desmanthus, I

Corolla gamopetalous, 5-cleft. Stamens 8 or 10. Pod minutely prickly or rough. Schrankia, II

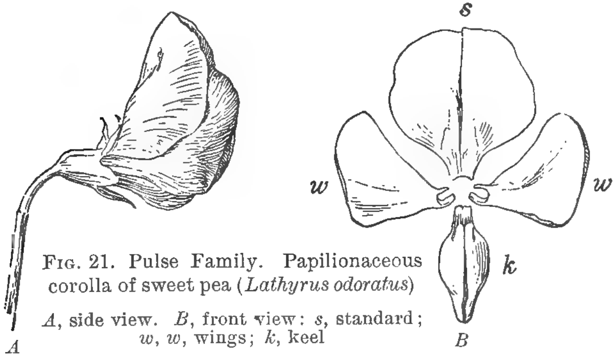


FIG. 21. Pulse Family. Papilionaceous corolla of sweet pea (*Lathyrus odoratus*)

A, side view. *B*, front view: *s*, standard; *w*, *w*, wings; *k*, keel

B

Trees. Flowers somewhat or not at all papilionaceous, sometimes almost actinomorphic. The upper petal inside the others in the bud. Stamens 10 or less, usually not united to each other, borne on the calyx.

Flowers imperfectly papilionaceous. Leaves simple. Cercis, V

Flowers not papilionaceous. Thornless. Gymnocladus, III

Flowers not papilionaceous. Thorny. Gleditsia, IV

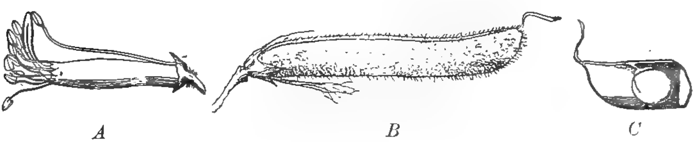


FIG. 22

A, stamens and pistil of sweet pea (magnified); *B*, fruit; *C*, part of fruit, showing one seed

C

Herbs or trees. Flowers decidedly papilionaceous. The upper petal external in bud and inclosing the others. Stamens 10, not united to each other.

Trees. Cladrastis, VII
Herbs. Pod inflated. Baptisia, VI
Herbs. Pod elongated, necklace-shaped. Sophora, VIII

D

Shrubs with a corolla of one petal only. Amorpha, XVI

E

Herbs, shrubs, or trees. Flowers decidedly papilionaceous. Stamens monadelphous or diadelphous (in the latter case usually 9 and 1).

1. Stamens with anthers of two forms.
   - (*a*) Herbs. Leaves usually with many leaflets. Lupinus, IX
   - (*b*) Herbs. Leaves with 3 entire leaflets. Psoralea, XV
   - (*c*) Trees. Laburnum, X
   - (*d*) Low shrubs. Cytisus, XI
2. Anthers all alike. Leaves usually with 3 leaflets.
   - (*a*) Pod coiled. Medicago, XIV
   - (*b*) Pod small, not coiled. Flowers in racemes. Melilotus, XIII
   - (*c*) Pod small, not coiled. Flowers in heads. Trifolium, XII
   - (*d*) Pod large, flattened, bur-like. Desmodium, XX
   - (*e*) Pod large, not much flattened. Phaseolus, XXIV
3. Anthers all alike. Leaves odd-pinnate, with more than 3 leaflets.
   - (*a*) Low, woody shrubs. Amorpha, XVI
   - (*b*) Tall, twining shrubs. Wisteria, XVIII
   - (*c*) Trees. Robinia, XVII
   - (*d*) Herbs. Astragalus, XIX
4. Anthers all alike. Leaves pinnate, the midrib prolonged into a tendril.

(*a*) Leaflets usually many pairs. Style slender, bearded only at the tip or all round the upper portion. Pod 2–several-seeded. Vicia, XXI

(*b*) Leaflets few or several pairs. Style bearded along one face only. Pod several-seeded. Lathyrus, XXII

(*c*) Leaflets 1–3 pairs. Style enlarged above, grooved on the back. Pod several-seeded; seeds large, globular or nearly so. Pisum, XXIII

I. DESMANTHUS Willd. (ACUAN)

Shrubs or perennial herbs. Stems erect or diffuse, smooth. Leaves abruptly twice-pinnate; stipules small. Flowers in heads or spikes, on axillary peduncles, the upper bisexual, the lower often staminate or neutral. Calyx 5-toothed. Corolla of 5 distinct petals or 5-cleft. Stamens 5–10, distinct. Ovary nearly sessile, flat, several-seeded.*

1. **D. illinoensis** Mac M. Desmanthus. Stem erect or ascending, smooth, 1–4 ft. high. Pinnæ 6–14 pairs, each with a minute gland at the base; leaflets 20–30 pairs, small, linear. Heads globose. Stamens 5. Pods several, on a peduncle 2–3 in. long, curved, flat, 2-valved, 3–6-seeded. Open, sandy fields.*

II. SCHRANKIA Willd. (MORONGIA)

Perennial herbs. Stems reclining or prostrate, prickly, 2–5 ft. long. Leaves twice-pinnate; stipules bristly. Flowers bisexual or somewhat monœcious, in axillary peduncled heads. Calyx minute. Corolla tubular, 5-cleft. Stamens 8–10, distinct. Pod long, prickly, 1-celled.*

1. **S. uncinata** Willd. Sensitive Brier, Sensitive Rose, Shame Vine. Plant covered with hooked prickles. Leaflets elliptical, with a conspicuous network of veins beneath; leaves closing gradually after being touched. Flowers rose-colored. Pods nearly cylindrical, 2 in. long. Dry, sandy soil and rolling prairies, especially S. and W.

III. GYMNOCLADUS Lam.

A large, thornless tree, its twigs few and stout. Leaves very large, twice pinnately compound, without stipules. Flowers actinomorphic, whitish, diœcious or somewhat monœcious, in racemes at the ends of the branches. Calyx tube rather long, its 5 lobes spreading. Petals oblong, all alike, inserted with the stamens on the throat of the calyx. Stamens of the fertile flowers usually not pollen-bearing. Pod hard, flat, partly filled with a sweet substance, slow in opening. Seeds several, flattish, over ½ in. in diameter, very hard and shining.

1. **G. dioica** Koch. KENTUCKY COFFEE TREE. Tree 50 ft. or more in height, with rough gray bark. Leaves 2–3 ft. long, the leaflets vertical. Pods sometimes nearly 1 ft. long. Rich soil and river bottoms, especially S. and W.

IV. GLEDITSIA L.

Large trees; bark dark-colored, nearly smooth. Leaves usually pinnately twice compound; leaflets serrate. Flowers somewhat monœcious, in small spike-like racemes. Calyx spreading, 3–5-cleft. Petals as many as the sepals and inserted at the summit of the tube. Stamens 5–10, distinct, inserted with the petals. Ovary nearly sessile, ovoid or elongated. Fruit a 1-or many-seeded, leathery pod.*

1. **G. triacanthos** L. HONEY LOCUST. A large tree, usually armed with stout, branched thorns, which are sometimes a foot or more in length. Leaves petioled; leaflets short-stalked, lanceolate-oblong, base inequilateral, smooth above, often downy below. Racemes solitary or in small clusters, drooping. Flowers inconspicuous, greenish. Pod linear-oblong, often 12–15 in. long by 1 in. wide, twisted, many-seeded, smooth and shiny, pulpy within. In rich woods.

V. CERCIS L.

Trees. Leaves simple, with stipules. Flowers in axillary clusters, somewhat papilionaceous. Calyx bell-shaped, 5-toothed. Stamens 10, distinct. Ovary short-stalked; ovules several. Fruit a flattened pod.

1. **C. canadensis** L. REDBUD. A small tree, 10–20 ft. high; wood hard but weak; bark smooth, dark-colored. Leaves broadly cordate, abruptly acute, rather thick, very smooth above, often slightly downy below. Flowers several in a cluster, appearing before the leaves, pinkish-purple. Pod oblong, compressed, many-seeded. Common on rich soil, especially S.*

VI. BAPTISIA Vent.

Perennial herbs; stems erect, widely branched. Leaves simple or palmate, of 3 leaflets. Flowers in racemes. Calyx 4–5-lobed, persistent, the upper lobe usually longer and notched; standard rounded, its sides reflexed, wings about as long as the keel. Stamens 10, distinct. Pod stalked, long-pointed by the remains of the style. Plants usually becoming black in drying.*

1. **B. tinctoria** R. Br. WILD INDIGO. Stem smooth, slender, 2–4 ft. high; branches slender. Leaves of 3 leaflets, on short petioles, the upper nearly sessile; stipules minute, quickly deciduous. Leaflets obovate to oblanceolate, obtuse at the apex, wedge-shaped at the base, entire. Racemes numerous, terminal. Flowers yellow, ½ in. long. Pod globose, ovoid, on a stalk about the length of the calyx, point long and slender. Plant blackening in drying. Common on dry, sandy soil.*

2. **B. bracteata** Muhl. Low, hairy, and branching. Leaves nearly sessile; leaflets oblanceolate or obovate-spatulate; stipules triangular-ovate, large, persistent; bracts large and leaf-like. Racemes long. Flowers large, yellowish-white. Pod ovoid, swollen. Prairies and open woods W. and S.

3. **B. leucantha** T. & G. Stout, smooth, and covered with a bloom, 3 ft. or more high, with spreading branches. Petioles short; lanceolate stipules and bracts falling off early. Racemes erect. Flowers large, white. Pods ellipsoidal, 2 in. long, borne on a stalk twice as long as the calyx. Rich river bottoms and prairies.

4. **B. alba** R. Br. WHITE WILD INDIGO. Stem smooth and with a bloom, often purple, 2–3 ft. high; branches slender, spreading. Leaves petioled, with 3 leaflets; stipules minute, soon deciduous. Flowers white, mostly in a single raceme which is 1–3 ft. long, with occasionally lateral, few-flowered racemes. Pod linear-oblong, the point very slender and soon deciduous. Plant unchanged in drying. In damp soil.*

5. **B. australis** R. Br. BLUE FALSE INDIGO. Stem smooth, stout, 2–4 ft. high. Leaves of 3 leaflets, short-petioled; stipules lanceolate, persistent, longer than the petioles; leaflets oblong, wedge-shaped or narrowly obovate, entire. Flowers bright blue, 1 in. long, in terminal, erect, loosely flowered racemes; stalk about the length of the calyx. Pod oblong, with a slender, persistent point. Banks of rivers; often cultivated for ornament.*

VII. CLADRASTIS Raf.

A moderate-sized tree, with smooth dark gray bark and yellow wood. Leaves of 7–11 smooth oval or ovate leaflets.

Flowers creamy-white, in long, drooping panicles. Calyx 5-toothed. Standard large, nearly round, reflexed; petals of the keel and wings separate and straight. Stamens 10, unconnected with each other. Pod borne on a short stalk above the calyx. Seeds 4–6.

1. **C. lutea** Koch. Yellow Wood. Tree 50 ft. or less in height, much branched, with a round, spreading top. Hillsides, in fertile soil, south central states. Also considerably planted as a shade tree.

VIII. SOPHORA L.

Shrubby or herbaceous perennials. Leaves odd-pinnate, with many leaflets. Calyx bell-shaped, with 5 short teeth. Standard roundish; keel nearly straight. Stamens almost or quite distinct; anthers versatile. Pod stalked, leathery or fleshy, nearly cylindrical but more or less contracted between the seeds, not splitting open.

1. **S. sericea** Nutt. Herbaceous with a woody base, erect, 6–12 in. high, covered with silky silvery down. Leaflets 7–25, obovate or nearly so, obtuse, narrowed at the base, $\frac{1}{4}$–$\frac{1}{2}$ in. long. Flowers white. Pod slender, dry, few-seeded. Prairies W. and S.W.

IX. LUPINUS L.

Biennial or perennial herbs. Leaves simple or palmately compound. Flowers showy, in terminal racemes. Calyx 2-lipped, 5-toothed. Standard round, with the sides reflexed; keel scythe-shaped. Stamens monadelphous; anthers alternately oblong and roundish. Ovary sessile; matured pod oblong, several-seeded, often compressed between the seeds.*

1. **L. perennis** L. Perennial. Stem erect, downy, 12–18 in. high. Leaves palmately 7–9-foliate; leaflets obovate or oblanceolate, obtuse and mucronate at the apex, slightly downy; petiole slender; stipules small. Racemes terminal, slender, loosely many-flowered. Flowers purple, blue, pink, or white. Pod oblong, densely downy, few-seeded. Dry, sandy soil.*

X. LABURNUM Medic.

Trees or shrubs. Leaves of 3 leaflets, with very small stipules or none. Flowers golden-yellow, in slender, drooping racemes. Calyx 2-lipped, the upper lip 2-toothed, the lower 3-toothed. Standard ovate, upright, of the same length as the straight wings. Stamens diadelphous (9 and 1). Ovary and pod somewhat stalked above the calyx, several-seeded.

1. **L. vulgare** Griseb. LABURNUM, GOLDEN CHAIN. A small tree, with smooth, greenish bark. Leaves with slender petioles; leaflets oblong-ovate, acute at the base, taper-pointed, downy beneath. Flowers showy, in graceful racemes. Cultivated from Europe.

XI. CYTISUS L.

Shrubs, rarely spiny. Leaves of 1–3 leaflets or none; stipules very small. Calyx 2-lipped, the upper lip slightly 2-toothed, the lower 3-toothed. Keel straight or a little curved, blunt, turned down after flowering. Stamens with their filaments all united; anthers every other one short and attached by its center, the alternate ones long and fastened by their bases. Style curved in, or, after the flower opens, coiled up. Pod flat, long, many-seeded.

1. **C. canariensis** Dumont. A shrub with many rather stiff, erect, slender branches. Leaves abundant, very small, covered with soft gray hairs; leaflets 3, obovate. Flowers rather small, yellow, in somewhat erect racemes. Cultivated in greenhouses. From the Canary Islands.

XII. TRIFOLIUM L.

Annual, biennial, or perennial herbs. Stems more or less spreading. Leaves petioled, of 3 toothed or serrate leaflets; stipules united to the petioles. Flowers white, yellow, or red, in heads. Calyx 5-cleft, the teeth nearly equal, awl-shaped. Petals withering-persistent; keel shorter than the wings. Stamens diadelphous. Pod smooth, 1–6-seeded, scarcely opening.*

1. **T. arvense** L. RABBIT FOOT CLOVER, STONE CLOVER. Annual, silky-downy, erect, branching, 5–10 in. high. Leaflets oblanceolate or linear, minutely toothed above. Heads terminal, peduncled. Calyx teeth very silky-hairy, longer than the whitish corolla. Old fields, railroad embankments, and waste ground. Naturalized from Europe.

2. **T. incarnatum** L. CRIMSON CLOVER. Annual. Stem erect, somewhat branched, downy, 1–2 ft. high. Lower leaves long-petioled, the upper short-petioled; leaflets obovate or wedge-shaped, toothed at the apex. Flowers bright crimson, sessile, in terminal heads which finally become much elongated. Calyx silky, its lobes long and plumose. Introduced from Europe and cultivated for fodder.

3. T. pratense L. Red Clover. Biennial or short-lived perennial. Stems spreading, branching, downy, 1–3 ft. long. Leaves long-petioled; stipules large; leaflets oval to obovate, finely toothed, often with a dark triangular spot near the center. Flowers red or purple, in globose heads, erect in fruit. Calyx teeth bristle-shaped, hairy. Pod 1–3-seeded. Introduced from Europe and widely cultivated.*

4. T. repens L. White Clover. Perennial. Stems widely branching at the base, prostrate and creeping, nearly smooth, 6–12 in. long. Leaves long-petioled; leaflets oval, obovate, or obcordate, minutely toothed. Heads globose, long-peduncled. Flowers white, reflexed in fruit. Pod 3–4-seeded. Common about houses and in pastures.*

5. T. hybridum L. Alsike Clover. Perennial, considerably resembling No. 4, but the stems more upright and stouter. Leaflets varying from broadly ovate to ovate-lanceolate, mucronate or slightly notched, the margins fringed with hairs; stipules prolonged into bristle-like points. Flowers rose color and white, very fragrant. In fields and along roadsides. Introduced from Europe.

6. T. carolinianum Michx. Carolina Clover. Perennial. Stems spreading or ascending, much-branched, downy, 6–10 in. long. Leaves short-petioled; leaflets small, obovate or obcordate, slightly toothed. Heads small, globose, on long peduncles. Flowers white, tinged with purple, reflexed in fruit. Pod 4-seeded. Common in waste places S.*

7. T. procumbens L. Low Hop Clover. Annual. Stem slender, erect or spreading, downy, 6–10 in. long. Leaves short-petioled; leaflets obovate or obcordate, finely dentate, the middle one distinctly stalked; stipules lance-ovate. Flowers yellow, reflexed in fruit. Pod 1-seeded. Common on clay soil, in waste places. Naturalized from Europe.*

XIII. MELILOTUS Hill.

Annual or biennial herbs. Leaves petioled, of 3 leaflets. Flowers small, white or yellow, in dense axillary and terminal racemes. Calyx 5-toothed, the teeth nearly equal. Standard erect, wings and keel cohering. Stamens 10, diadelphous. Pod longer than the calyx, 1–4-seeded.*

1. M. alba Lam. Melilotus. Biennial. Stem erect, branching, smooth or the young branches slightly downy. Leaflets oblong or oblanceolate, rounded or truncate at the apex, serrate; stipules small. Racemes long, slender, erect. Flowers white. Standard longer than the wings and keel. Pod ovoid, wrinkled, drooping, mostly 1-seeded, scarcely opening. Common as a weed and widely cultivated.*

2. M. officinalis Willd. YELLOW SWEET CLOVER. A stout, upright, branching herb, 2–4 ft. high, looking much like the preceding species, but coarser. Flowers yellow. Waste ground and roadsides. Naturalized from Europe.

XIV. MEDICAGO L.

Annual or perennial herbs. Leaves petioled, of 3 toothed leaflets. Flowers in terminal and axillary spikes or racemes. Calyx 5-toothed, the teeth short and slender. Standard oblong, much longer than the wings or keel. Stamens 10, diadelphous. Ovary sessile. Pod 1–several-seeded, coiled, not splitting open, often spiny.*

1. M. sativa L. ALFALFA. Perennial. Stems erect, branching, downy when young, becoming smooth with age, 2–3 ft. high. Leaves short-petioled; leaflets obovate, sharply dentate towards the apex, obtuse or sometimes notched or mucronate; stipules lanceolate, entire. Flowers blue, small, in rather close spikes. Pods downy, coiled, few-seeded. Introduced from Europe, and cultivated for hay and pasture.*

2. M. lupulina L. BLACK MEDICK, NONESUCH. An annual or biennial, much-branched, reclining herb, with stems 6–20 in. long. Leaves very short-petioled; leaflets obovate, acute, $\frac{1}{4}$–$\frac{2}{3}$ in. long, toothed near the tip. Flowers small, yellow, in short spikes. Pods very small, 1-seeded, kidney-shaped, black. Roadsides and waste ground, adventive from Europe.

XV. PSORALEA L.

Perennial herbs; whole plant glandular-dotted. Leaves of 3–5 leaflets; stipules united with the petioles. Flowers in axillary or terminal spikes or racemes. Calyx 5-cleft, the lobes nearly equal. Standard ovate or orbicular; keel incurved, obtuse. Stamens monadelphous or diadelphous, 5 of the anthers often undeveloped. Ovary nearly sessile. Pod included in the calyx, often wrinkled, remaining closed, 1-seeded.*

1. P. pedunculata Vail. SAMSON'S SNAKEROOT. Stem erect, slender, branching above, downy, 1–2 ft. high. Leaves of 3 leaflets; petioles shorter than the leaflets; stipules awl-shaped; leaflets elliptical or oblong-lanceolate, sparingly glandular-dotted, the terminal one stalked. Loosely flowered spikes axillary and terminal, on peduncles much longer than the leaves. Flowers blue or purple, about $\frac{1}{3}$ in. long. Pod compressed-globose, wrinkled transversely. Dry soil.*

2. P. tenuiflora Pursh. Upright, slender, bushy and branching, 2–4 ft. high, covered when young with a fine grayish down. Leaves palmately compound, with 3–5 linear to obovate-oblong leaflets, covered with glandular dots. Flowers $\frac{1}{6}$–$\frac{1}{4}$ in. long, loosely racemed. Pod rough with glands. Prairies W.

3. P. argophylla Pursh. Silver-Leaved Psoralea. Densely silvery downy, with white, close-lying hairs. Stem often zigzag, 1–3 ft. high. Leaves palmate; leaflets 3–5, elliptical-lanceolate, oval or obovate. Spikes interrupted, the peduncles longer than the leaves. Flowers blue or purplish, $\frac{1}{3}$ in. or more long. Pod ovate, beak straight. Prairies, especially N.W.

4. P. esculenta Pursh. Pomme Blanche, Tipsin, Dakota Turnip. Clothed with roughish hairs. Stem 5–15 in. high, erect and stout. Root turnip-shaped, starchy, eatable. Leaves palmately compound, with 5 lance-oblong leaflets. Flowers $\frac{1}{2}$ in. long, in a dense ellipsoidal spike. Pod hairy, with a pointed tip. High prairies or plains, especially N.W.

XVI. AMORPHA L.

Small shrubs, glandular-dotted. Leaves odd-pinnate. Flowers purple, blue, or white, in slender spikes or racemes. Calyx 5-toothed, persistent. Standard obovate, concave; wings and keel none. Stamens monadelphous, projecting much. Ovary sessile. Pod curved, glandular-roughened, 1–2-seeded, never opening.*

1. A. canescens Pursh. Lead Plant, Shoe Strings. A bushy, white, silky-downy shrub, 1–3 ft. high. Leaflets small and crowded, 21–49, oval or oblong-elliptical. Spikes mostly clustered at the summit, rather showy. Standard bright blue, roundish. Pod 1-seeded, slightly longer than the calyx. Prairies. Roots very long and tough, hence one common name.

2. A. microphylla Pursh. A bushy shrub about 1 ft. high. Leaves many, short-petioled; leaflets 13–19, rigid, oval or oblong. Racemes mostly solitary. Flowers fragrant; standard purplish. Prairies, especially N.W.

3. A. fruticosa L. False Indigo. A shrub, 6–15 ft. high, with smooth, dark-brown bark. Leaves petioled; leaflets 15–21, short-stalked, oblong, obtuse or notched, sparingly punctate with clear dots. Slender flowering spikes, panicled or solitary, 4–6 in. long. Flowers blue or purple. Calyx teeth short, nearly equal, downy. Pod glandular. River banks.*

XVII. ROBINIA L.

Trees or shrubs. Leaves odd-pinnate; stipules often spiny. Flowers showy, in axillary racemes. Calyx short, 5-toothed, the two upper teeth shorter and partially united. Standard large, orbicular, reflexed, keel obtuse. Stamens diadelphous. Style bearded on one side. Pod compressed, several-seeded.*

1. **R. Pseudo-Acacia** L. BLACK LOCUST. A tree of medium size; bark rough and nearly black; twigs and leaves smooth. Leaflets 9–15, ovate or oblong, obtuse and slightly mucronate at the apex; stipules forming persistent spines. Racemes loose, pendulous, 3–5 in. long. Flowers white, fragrant. Pod smooth, 4–8-seeded. Introduced, and quite common; wood very durable when exposed to the weather, and extensively used for posts.*

XVIII. WISTERIA Nutt. (BRADLEYA)

Tall, twining shrubs. Leaves odd-pinnate. Racemes terminal. Flowers large and showy. Calyx 2-lipped, the upper lip 2-cleft, short, the lower longer and 3-cleft. Standard large, round, with 2 calloused ridges at the base; wings eared at the base; keel scythe-shaped. Pod long, stalked, leathery, 2-valved, several-seeded.*

1 **W. frutescens** Poir. WISTERIA. Stem climbing 30–40 ft., often 2–3 in. in diameter at the base; branches and leaves downy when young, becoming smoother with age. Leaves short-petioled; stipules minute; leaflets 9–17, ovate-lanceolate, acute at the apex, rounded at the base. Racemes large, densely flowered. Calyx downy. Corolla lilac-purple, wings with a short and a long appendage at the base. Pod 2–3 in. long, 2–4-seeded. River banks S. Often cultivated for ornament.*

2. **W. chinensis** DC. CHINESE WISTERIA. Larger and faster growing than No. 1. Racemes longer and more slender. Wing appendage at one side only of base. Seldom fruiting in this region. Cultivated from China or Japan.

XIX. ASTRAGALUS L.

Mostly perennial herbs. Leaves odd-pinnate. Flowers in spikes or racemes. Calyx 5-toothed. Petals long, erect, with claws. Standard narrow. Stamens diadelphous (9 and 1). Pod usually swollen, sometimes fleshy and eatable, several–many-seeded. [A large and very difficult genus; mostly of far western species.]

1. A. caryocarpus Ker. GROUND PLUM, BUFFALO APPLE. Covered with pale, close-lying down. Leaflets narrow, oblong. Flowers violet-purple, in a short, narrow raceme. Fruit looking like a small, green, pointed plum, about $\frac{2}{3}$ in. in diameter, eatable. N.W., and S. to Texas.

2. A. mexicanus A. DC. PRAIRIE APPLE. Smooth or with some loose hairs. Corolla cream color, with the tip bluish. Fruit globular, not pointed, eatable. Prairies, Illinois and S.W.

3. A. canadensis L. Erect, often tall (1–4 ft. high), more or less downy. Leaflets oblong, 21–27. Flowers pale greenish, in long spikes. Pod dry, 2-celled, sessile. River bottoms, prairies, and woods.

4. A. parviflorus MacM. Erect and slender, finely downy, somewhat ash-color, 1–2 ft. high. Leaflets 11–21, linear, obtuse, distant. Flowers purple, $\frac{1}{4}$–$\frac{1}{3}$ in. long, in long, slender racemes. Pods sessile, $\frac{1}{4}$ in. or less in length, concave on the back, white-hairy, becoming smooth. Prairies, especially N.W.

XX. DESMODIUM Desv. (MEIBOMIA)

Perennial herbs. Leaves pinnate, with stipules, usually with 3 leaflets. Flowers in axillary or terminal racemes, or sometimes in panicles, usually purple, sometimes pink or whitish. Calyx usually somewhat 2-lipped. Standard ovate, obovate, or roundish; wings attached to the straight or nearly straight keel by a little appendage projecting from each side of the keel. Stamens monadelphous (9 and 1) or all united at their bases. Pod flat, its lower margin variously lobed, separating into flat segments which are usually furnished with short, strong, hooked hairs, making the fruit a troublesome bur. [A large and rather difficult genus. Most of the species can only be distinguished by the fruit, which matures in late summer or autumn.]

XXI. VICIA L.

Climbing or spreading herbs. Leaves odd-pinnate, usually ending in a tendril. Leaflets many, entire or toothed at the tip; stipules half arrow-shaped. Flowers blue, purple, or yellow, in axillary racemes. Calyx teeth nearly equal. Wings united to the keel. Stamens diadelphous (9 and 1); filaments thread-shaped; anthers all alike. Style bent, smooth or downy all round or bearded below the stigma; ovules usually many. Pod flattened, 2–several-seeded. Seeds globular.

1. V. sativa L. Common Vetch. Annual. Stem simple, smooth, reclining, 1–3 ft. long. Leaves short-petioled; leaflets 2–5 pairs, obovate-oblong to linear, obtuse, notched and mucronate at the apex. Flowers in pairs, nearly sessile in the axils, pale purple, $\frac{3}{4}$ in. or less in length. Pod linear, several-seeded. In gravelly soil. Introduced from Europe.

2. V. caroliniana Walt. Perennial. Smooth or nearly so, 4–6 ft. high. Leaflets 8–24, narrowly oblong, blunt. Peduncles loosely flowered. Flowers small, whitish or tipped with pale purple. River banks.

3. V. americana Muhl. Wild Vetch, Buffalo Pea. Perennial. Smooth, 1–3 ft. high. Leaflets 10–14, elliptical or ovate-oblong, obtuse. Peduncles shorter than the leaves, 4–8-flowered. Flowers bluish-purple, $\frac{3}{4}$ in. long. Common N. and W.

XXII. LATHYRUS L.

Like *Vicia*, excepting that the leaflets are fewer and the style is bearded on the side toward the standard.

1. L. maritimus Bigelow. Beach Pea. Perennial. Stem stout, 1–2 ft. high. Stipules broadly ovate and heart- or halberd-shaped, nearly as large as the 6–12 leaflets, of which the lower pair is the largest; tendrils pretty large. Flowers large, blue or purple. Seashores and beaches of the Great Lakes.

2. L. palustris L. Wild Pea. Stem frequently winged, slender, and climbing by delicate tendrils at the ends of the leaves. Stipules narrow and pointed; leaflets 4–8, narrowly oblong to linear, acute. Peduncles bearing 2–6 pretty large, drooping, blue, purple, and white flowers. Damp thickets and borders of swamps.

3. L. venosus Muhl. Veiny Vetch. Perennial. Stem stout, prominently angled, climbing or reclining, 2–5 ft. long. Leaves short-petioled; stipules large, lanceolate; leaflets 5–7 pairs, broadly ovate-obtuse, mucronate. Peduncles nearly as long as the leaves, many-flowered. Flowers purple, $\frac{3}{4}$ in. long. Calyx teeth very unequal. Pod linear, veined, 4–6-seeded. Shady banks and moist prairies.*

4. L. odoratus L. Sweet Pea. Annual. Stem roughish-hairy, it and the petioles winged. Leaflets only one pair, oval or oblong. Flowers large, 2 or 3 on the long peduncles, sweet-scented, white, rose color, purple, or variegated. Cultivated from Europe.

XXIII. PISUM L.

Climbing or prostrate herbs. Style enlarged above, grooved on the back, with soft-hairy down on the inner edge. Leaflets 1–3 pairs. Flowers and fruit much like those of *Lathyrus*.

1. **P. sativum** L. COMMON PEA. Annual. Smooth and covered with a bloom. Leaflets usually 2 pairs; tendrils branching; stipules large, ovate, rather heart-shaped at the base. Peduncle several-flowered. Flowers white, bluish, reddish, or variegated. Pods large; seeds globular or somewhat flattened and wrinkled. There are many varieties, differing greatly in size, of the plant and of the fruit. Cultivated from Europe (?).

XXIV. PHASEOLUS L.

Twining herbs. Leaves pinnate, of 3 leaflets. Flowers in axillary racemes. Calyx 5-toothed or 5-cleft, the two upper teeth often more united than the others. Keel of the corolla coiled in a spiral, together with the included stamens and style. Stamens diadelphous (9 and 1). Style bearded lengthwise on the upper side; stigma oblique or on the side of the style. Pod linear, 2-valved, several–many-seeded, tipped with the remains of the style.

1. **P. perennis** Walt. WILD BEAN. Perennial, climbing high. Flowers small, purple. Pods curved, drooping, 4–6-seeded. Thickets.

2. **P. vulgaris** L. COMMON or KIDNEY BEAN. Twiners (or some varieties low and branching). Racemes of white or purplish flowers shorter than the leaves. Pods straight or nearly so. Seeds not much flattened. Cultivated, probably from tropical America.

3. **P. multiflorus** Willd. SPANISH BEAN, SCARLET RUNNER. Stems twining high. Flowers large and showy, white, scarlet, or variegated; racemes longer than the leaves. The scarlet variety is the most commonly cultivated, for ornament. From tropical America.

48. GERANIACEÆ. GERANIUM FAMILY

Herbs or small shrubs. Leaves simple, usually with glandular hairs which secrete an aromatic oil. Flowers bisexual, axillary and solitary or clustered, actinomorphic or nearly so, hypogynous, their parts in fives. Stamens 5 or 10, monadelphous at the base. Carpels 5, each 2-ovuled, splitting away with their long styles when ripe from a central axis and thus scattering the seeds.

I. GERANIUM L.

Herbs, rarely shrubs. Leaves with stipules, opposite or alternate, usually cut or lobed. Flowers actinomorphic on

1–2-flowered axillary peduncles. Sepals and petals 5. Stamens 10, ripening in 2 sets. Ovary 5-lobed, 5-beaked; stigmas 5.

1. G. maculatum L. WILD CRANE'S-BILL, WILD GERANIUM. Perennial, with an erect, hairy stem, 12–18 in. high. Leaves about 5-parted, marked with pale blotches, the basal leaves long-petioled. Flowers large (1 in. or more in diameter), light purple, somewhat corymbed. Petals entire, twice as long as the calyx, the claw bearded. Open woods and thickets; common.

2. G. Robertianum L. HERB ROBERT. Annual or biennial. Stems somewhat hairy, weak and spreading, reddish. Leaves of 5 leaflets, the latter once or twice pinnately cut, long-petioled. Flowers light purple, about ½ in. in diameter, streaked with dark and light red. Claws of petals smooth. Damp woods and ravines E.

II. PELARGONIUM L'Her.

Perennial herbs or shrubs. Leaves with stipules, scented. Flowers much as in the preceding genus, but one of the sepals hollowed out below into a nectar-bearing tube extending down the pedicel. The 2 upper petals different in size or shape from the other 3. Cultivated from the Cape of Good Hope. [Most of the species are commonly, though not quite correctly, called "geraniums." Only a few of the commonest are here described.]

1. P. peltatum Ait. IVY GERANIUM. Stems somewhat prostrate and trailing. Leaves somewhat peltate, smooth or nearly so. Flowers pink or white.

2. P. zonale Willd. HORSESHOE GERANIUM. Stem erect, widely branched, woody below. Leaves alternate, opposite or sometimes in threes, round or kidney-shaped, palmately veined, crenate, downy, usually with a dark zone near the middle. Flowers in a long peduncled umbel, showy, red or white, often double. Numberless varieties in cultivation.

3. P. graveolens Ait. ROSE GERANIUM. Stem erect or ascending, densely downy, 1–3 ft. high. Leaves alternate, palmately lobed or divided, the lobes often finely dissected, rolled under at the edges. Flowers umbeled, small, light purple with darker veins; whole plant very fragrant. Common in cultivation.

4. P. odoratissimum Ait. NUTMEG GERANIUM. Branches crooked and straggling from a very short, moderately stout main stem. Leaves small, roundish and scalloped, covered with velvety down, very fragrant. Flowers white, inconspicuous, on short pedicels the petals hardly longer than the calyx.

49. OXALIDACEÆ. Wood Sorrel Family

Herbs or woody plants. Leaves compound. Flowers in fives, bisexual, actinomorphic, hypogynous. Stamens 10, somewhat monadelphous at the base. Ovary with several ovules in each cell. Fruit a capsule.

OXALIS L.

Acid herbs. Leaves basal or alternate, with or without stipules, usually of 3 leaflets, which droop at night. Sepals 5. Petals 5. Stamens 10. Ovary 5-lobed, 5-celled; styles 5.

1. O. Acetosella L. Wood Sorrel. Apparently stemless, from a creeping, scaly rootstock. Leaves all basal, long-petioled, of 3 inversely heart-shaped leaflets; scape slender, 2–5 in. high, 1-flowered. Flowers nearly 1 in. in diameter, white, veined with red or purple. Cold woods N.

2. O. violacea L. Violet Wood Sorrel. Perennial from a bulbous root, apparently stemless. Leaves long-petioled; leaflets inversely heart-shaped, sometimes slightly downy, often with a dark zone near the middle. Scapes usually longer than the petioles, umbellately 4–10-flowered; pedicels slender. Flowers violet-purple, nodding. Petals obtuse, 2–3 times as long as the sepals; scapes and petioles 4–5 in. long. Common in rich woods.*

3. O. corniculata L. Common Yellow Wood Sorrel. Probably flowering the first year but perennial, propagated by slender whitish rootstocks. Erect or decumbent, often sparsely hairy, usually 1 ft. or less in height. Stem leafy, the leaves often appearing whorled. Leaflets thin, green or purplish, often ciliate. Peduncles few-flowered, the ascending pedicels, clad with spreading hairs, forming unsymmetrical umbels or cymes at their summits. Flowers yellow, about $\frac{1}{3}$ in. in diameter. Pods hairy, columnar, grooved, often $\frac{1}{2}$ in. or more in length. A common weed in light soil.

50. TROPÆOLACEÆ. Indian Cress Family

Smooth and tender herbaceous plants, with biting juice, often climbing by the petioles of their simple leaves. Leaves alternate, without stipules. Peduncles axillary, 1-flowered. Sepals 3–5, the upper one with a long, distinct spur. Petals 1–5, hypogynous, not always all alike. Stamens 6–10, perigynous, distinct. Ovary 1, 3-angled, made up of 3–5 1-ovuled carpels; style 1; stigmas 3–5. Fruit not opening.

TROPÆOLUM L.

Characteristics of the genus those of the family above given, together with the following:

Petals usually 5, clawed, the 2 upper inserted at the mouth of the spur and unlike the 3 lower ones. Stamens 8, ripening unequally, the filaments curved. Fruit 3-celled, 3-seeded. Cultivated from S.A. for the very showy flowers and the sharp-flavored fruits, which are often pickled.

1. **T. majus** L. COMMON NASTURTIUM. Climbing by the petioles 6–8 ft. (there is also a low variety which does not climb). Leaves roundish but more or less 6-angled, peltate, with the petiole attached near the middle. Flowers varying from almost white to nearly black, but commonly crimson, scarlet, or flame color.

51. LINACEÆ. FLAX FAMILY

Herbs, shrubs, or trees. Leaves usually alternate, simple, entire, sometimes with stipules. Flowers variously clustered. Sepals 5, distinct or united. Petals 5, hypogynous. Stamens 5, monadelphous below. Pod 8–10-seeded, with twice as many cells as there are styles.

LINUM L.

Herbs or small shrubs, with tough, fibrous bark. Leaves sessile. Flowers in corymbs or panicles. Sepals 5, entire. Petals 5, distinct or united below, falling in a few hours after expanding.

1. **L. usitatissimum** L. COMMON FLAX. Stem erect, with corymbed branches at the top. Leaves narrowly lanceolate. Flowers handsome, large, blue. Cultivated for the fiber. From Europe; introduced here to some extent.

2. **L. virginianum** L. WILD FLAX. Stem rather slender, erect and cylindrical; branches cylindrical. Leaves small, varying from oblong to lanceolate or spatulate, the lower often opposite. Flowers small, yellow. Capsules flattened at right angles to the pedicels. Dry woods and pastures.

52. RUTACEÆ. Rue Family

Shrubs or trees. Leaves alternate, compound, without stipules, marked with translucent dots. Flowers usually actinomorphic. Sepals and petals 3–5 or none; petals hypogynous or perigynous when present. Stamens as many or twice as many as the sepals, inserted on the glandular disk. Pistils 2–5, often partially united. Fruit a capsule, a key fruit, or in the important genus *Citrus* (orange, lemon, lime, etc., not here described) a leathery-skinned berry, the outer part of the skin containing many spherical oil cavities.*

I. XANTHOXYLUM

Trees or shrubs; bark, twigs, and petioles usually prickly; leaves odd-pinnate, marked with translucent dots. Flowers in axillary or terminal cymes or umbels, monœcious or diœcious. Sepals and petals 3–5 or none. Stamens 3–5, hypogynous. Pistils 2–5, distinct. Carpels 2-valved, 1–2-seeded; seeds smooth and shining.*

1. **X. americanum** Mill. Northern Prickly Ash, Toothache Tree. A prickly shrub, 8–12 ft. high, with aromatic bark. Leaves pinnately compound; leaflets ovate-oblong. Flowers small and greenish, in axillary umbels, appearing before the leaves. Petals 4–5. Pistils 3–5, the styles slender. Pods rather globose, somewhat more than $\frac{1}{8}$ in. in diameter, roughish, borne on a short stalk above the receptacle, with a strong scent of lemon and tasting at first aromatic, then burning. Rocky woods, ravines, and river banks.

II. PTELEA L.

Shrubs with smooth and bitter bark. Leaves with 3 leaflets. Flowers in terminal cymes, somewhat monœcious. Sepals 3–6, deciduous, much shorter than the petals. Stamens 4–5, longer than the petals and alternate with them. Pistillate flowers producing imperfect stamens. Ovary compressed, 2-celled. Fruit a 2-celled, 2-seeded, broadly winged key.*

1. **P. trifoliata** L. Hop Tree, Wafer Ash. A shrub 4–8 ft. high. Leaves long-petioled; leaflets oval or ovate, acute, obscurely serrate,

the lateral ones oblique. Cymes compound. Flowers greenish. Stamens mostly 4; filaments bearded; key about 1 in. in diameter; wing notched, strongly netted-veined. Rocky banks; often cultivated.*

53. POLYGALACEÆ. Polygala Family

Herbs or shrubs. Leaves alternate or nearly opposite, without stipules, simple. Flowers not actinomorphic. Sepals unequal, the 2 inner wing-shaped and petal-like. Petals 3–5, hypogynous, the 2 lateral ones often united with the hooded lower one into a tube, split open at the base behind. Stamens 8; filaments united into a split sheath, which is usually joined to the petals; anthers usually opening by pores. Ovary 2-celled, 2-ovuled. [A difficult family for the beginner.]

POLYGALA L.

Herbs or shrubs. Flowers racemed or spiked, some of them often cleistogamous. Petals united below to the stamen sheath. Anthers opening by transverse pores.

1. **P. paucifolia** Willd. Fringed Polygala, Babies' Toes, May Wings. A low perennial herb, with branches 3–4 in. high, from a slender, creeping rootstock. Lower leaves scattered, small and scale-like, the upper ones with petioles, crowded near the tips of the branches, ovate or nearly so. Flowers of two kinds, the cleistogamous whitish, fertile, borne underground along the rootstock, the terminal flowers large and showy (nearly an inch long), rose-purple, with a beautiful fringed crest. Woods, especially N. and E.

2. **P. Senega** L. Seneca Snakeroot. A perennial herb, with several erect stems arising from stout, hard, knotty rootstocks. Leaves lanceolate, oblong or lance-ovate, sessile. Flowers all alike, small, white, in solitary close spikes. Rocky woods.

54. EUPHORBIACEÆ. Spurge Family

Herbs, shrubs, or trees, usually with a milky, more or less acrid and sometimes poisonous juice. Flowers mostly apetalous, monœcious or diœcious (Fig. 23). Ovary usually 3-celled, with 1 or 2 ovules in each cell; stigmas as many as the cells or twice as many. Fruit a 3-lobed capsule. Seeds containing fleshy or oily endosperm. Most of the family are natives of hot regions, many of them of peculiar aspect from their adaptation to life in dry climates. [The family is too difficult for the beginner in botany to determine many of its genera and species with certainty, but a few are described below.]

I. JATROPHA L.

Shrubs or herbs. Leaves alternate. Flowers monœcious, staminate and pistillate intermixed in the cymes, apetalous. Calyx large, white, 5-lobed, corolla-like. Stamens numerous, usually monadelphous. Ovary usually 3-celled, 3-seeded; styles 3, united at the base, several-parted.*

1. **J. stimulosa** Michx. SPURGE NETTLE. Perennial herbs armed with stinging hairs; stems erect, branched, bright green with white lines, 8–15 in. high. Leaves long-petioled, deeply palmately 3–5-lobed, the lobes irregularly cut and toothed, often mottled. Sepals white, spreading. Seeds oblong, smooth, mottled. In dry woods S.*

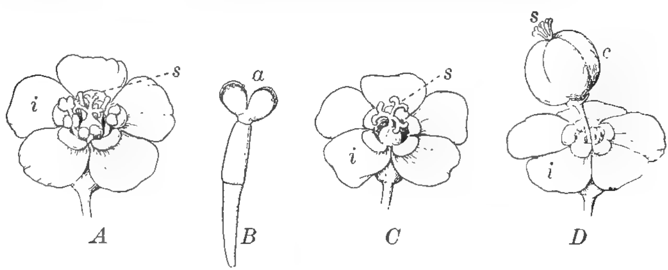


FIG. 23. *Euphorbia corollata*

A, flower cluster with involucre, the whole appearing like a single flower. *B*, a single staminate flower: *a*, anther. *C*, fertile flower, as seen after the removal of the sterile flowers. *D*, partly matured fruit: *i*, involucre; *s*, stigmas; *c*, capsule

II. EUPHORBIA L.

Herbs or shrubs, with milky juice, often poisonous. Flowers monœcious, inclosed in a 4–5-lobed involucre, which is often showy and resembles a calyx or corolla, usually bearing large glands at its notches. Sterile flowers many, borne inside the involucre at its base (Fig. 23, *A*), each consisting only of a single stamen attached by a joint to a pedicel which looks like a filament. Fertile flower standing alone at the center of the involucre (Fig. 23, *C*) (soon pushed out by the growth of its pedicel), consisting only of a 3-lobed and 3-celled ovary, 3 2-cleft styles, and 6 stigmas. Pod 3-celled and 3-seeded.

A. *Cultivated shrubs.*

1. E. splendens Bojer. CROWN OF THORNS. An extremely prickly shrub, with many erect, few-leaved branches. Leaves obovate or obovate-spatulate, mucronate, entire, each with two very sharp prickles (longer than the petiole) as stipules. Peduncles long, sticky, each bearing 2–4 objects which appear to be showy scarlet flowers, but which are actually 2-bracted involucres containing the true flowers. Involucral scales somewhat kidney-shaped, mucronate. Flowering all the year round. Cultivated in greenhouses. From Mauritius.

B. *Herbs with rather showy white flower clusters.*

2. E. marginata Pursh. SNOW ON THE MOUNTAIN. Annual. Stem stout, 1–3 ft. high. Leaves sessile, ovate, obovate or oblong, acute, $\frac{3}{4}$–3 in. long, the upper ones whorled and with white petal-like margins. Involucres 5-lobed in an umbel-like inflorescence with three forking rays. In dry soil W. and commonly cultivated.

3. E. corollata L. FLOWERING SPURGE. Perennial. Stem erect, umbellately branched above, smooth or downy, 1–3 ft. high. Leaves of the stem alternate, those of the branches usually opposite or whorled, rather thick, oval to narrowly oblong, pale beneath, usually slightly downy. Flowering branches repeatedly forked; involucres terminal and in the forks of the branches, peduncled; glands 4–5, oblong, green; appendages white and petal-like, showy. Capsule erect, seed smooth or faintly pitted. Common in dry, open woods.

C. *Herbs: No. 4 a native species: No. 5 cultivated from Europe or escaping from gardens. Flower clusters in umbels, not white. Involucre 4- or 5-lobed, each lobe with a gland.*

4. E. dictyosperma Fisch. & Mey. Annual. Stem slender, 8–18 in. high, erect. Stem leaves oblong-spatulate to obovate, serrate; floral ones roundish-ovate, somewhat heart-shaped. Flower cluster a compound umbel, the rays once or twice 3-forked, then 2-forked. Seeds covered with a network. Prairies and roadsides.

5. E. **Cyparissias** L. Cypress Spurge, Cypress, Graveyard Moss. A perennial, in dense clusters 6–12 in. high, from running rootstocks. Leaves much crowded, all sessile, the stem leaves linear, floral ones broadly heart-shaped. Flower cluster a simple, many-rayed umbel. Glands crescent-shaped. Cemeteries, roadsides, etc., escaped from cultivation; also cultivated in old gardens. From Europe.

55. ANACARDIACEÆ. Sumac Family

Trees or shrubs, with resinous, acrid, or milky sap. Leaves simple, of 3 leaflets or pinnately compound, alternate, without stipules. Flowers bisexual or unisexual, small. Calyx 3–5-parted, persistent. Petals 3–5 or wanting. Stamens as many as the sepals or sometimes twice as many, inserted in the base of the calyx, distinct. Ovary free, 1-celled; styles 1–3. Fruit a 1-seeded drupe.*

RHUS L.

Trees or shrubs. Leaves of 3 leaflets or odd-pinnate. Flowers in spikes or panicles. Calyx mostly 5-parted. Petals and stamens 5. Pistil 1, sessile; styles 3, terminal. Fruit small, smooth or downy.*

1. R. **typhina** L. Stag-Horn Sumac. A small tree, 20–40 ft. high; branches and petioles closely velvety-hairy. Leaves odd-pinnate, leaflets 17–27, lanceolate-oblong, taper-pointed at the apex, very obtuse at the base, sharply serrate, smooth above, pale and downy beneath. Flowers somewhat monœcious, in dense terminal panicles. Fruit red, with crimson hairs. Dry hillsides N. and E.*

2. R. **glabra** L. Sumac. A shrub or small tree, sometimes 25–30 ft. high; branches downy. Leaves odd-pinnate, main midrib downy and wing-margined; leaflets 9–21, ovate-lanceolate, acute at the apex, inequilateral, entire or slightly toothed, smooth and green above, pale and downy beneath. Panicle often large and spreading; flowers somewhat monœcious. Fruit red, hairy, acid. Open woods.*

3. R. **Vernix** L. Poison Sumac, Poison Dogwood. A very smooth shrub with gray bark, 6–18 ft. high. Leaves large and glossy, with 7–13 obovate-oblong, entire leaflets. Flower clusters loosely flowered, axillary panicles. Fruit smooth, greenish-yellow. Swamps and wet openings in woods N. and E. Plant more poisonous than the following species.

4. R. Toxicodendron L. POISON VINE, POISON IVY, MERCURY, BLACK MERCURY. Stem a woody vine climbing high by aërial rootlets, or sometimes short and erect. Leaves petioled, of 3 leaflets, downy; leaflets ovate or oval, taper-pointed, entire or somewhat dentate, often angled or lobed. Flowers diœcious, in loose axillary panicles. Fruit nearly white, smooth. Common in open woods and along fences. . Plant poisonous to the touch.*

56. AQUIFOLIACEÆ. HOLLY FAMILY

Trees or shrubs. Leaves simple, alternate, petioled; stipules small or wanting. Flowers small, greenish, clustered or solitary in the axils, usually diœcious. Calyx 4–9-parted. Petals 4–9, somewhat united at the base. Stamens inserted in the tube of the corolla and alternate with its lobes. Ovary free, 4–9-celled, with a single ovule in each cell. Fruit a berry-like drupe, 4–9-seeded.*

ILEX L.

Small trees or shrubs. Leaves usually leathery, often persistent and evergreen; stipules minute. Flowers axillary, 4–9-parted, the fertile often solitary and the staminate clustered. Fruit a drupe with 4–9 nutlets.*

1. I. opaca Ait. HOLLY. Trees with smooth, light-colored bark, and hard, very white wood; young twigs downy. Leaves leathery, oval or ovate, margin prickly-toothed, dark green and shining above, paler and sometimes slightly downy beneath. Peduncles short, bracted. Flowers 4-parted; staminate flowers in small cymes, the pistillate ones usually solitary. Fruit bright red. Damp, sandy soil E. and S.*

2. I. decidua Walt. DECIDUOUS HOLLY. Small trees; twigs smooth. Leaves thin, obovate, obtuse or sometimes acute at the apex, scalloped, smooth, deciduous. Flowers in sessile clusters, 4–6-parted. Fruits very numerous, bright red. On low ground S.*

3. I. verticillata Gray. BLACK ALDER, WINTERBERRY. A much-branched shrub 6–8 ft. high. Leaves thin, oval or obovate, taper-pointed, serrate, 1½–2 in. long. Flowers greenish-white, on very short peduncles. Fruit bright red, 1, 2, or 3 in a leaf axil, remaining long after the leaves have fallen. Swampy ground and damp woods and thickets.

57. CELASTRACEÆ. Wahoo Family

Trees or shrubs, sometimes climbing. Leaves simple, opposite or alternate. Flowers small, in cymes. Calyx small, 4-5-lobed, persistent. Petals 4–6, short. Stamens 4–6, alternate with the petals and inserted with them on a disk. Ovary sessile, 3–5-celled; style entire or 3–5-cleft; ovules 2 in each cell. Seeds usually covered with an appendage (aril) growing from the hilum.

I. EVONYMUS L.

Shrubs with 4-angled branches. Leaves opposite. Flowers in axillary, peduncled cymes, purplish or greenish, small. Sepals and petals 4–5, spreading. Stamens as many as the petals, short. Ovary 3–5-celled, with 2 ovules in each cell. Seeds inclosed in a red, fleshy pulp.*

1. **E. atropurpureus** Jacq. Wahoo. A tree-like shrub 10–15 ft. high. Leaves oval to ovate, taper-pointed, finely serrulate, minutely downy petioles ½–¾ in. long. Peduncles slender, 3-forked, several-flowered. Flower purplish. Capsule deeply 3–5-lobed, smooth. River banks.

2. **E. americanus** L. Strawberry Bush. A shrub 3–8 ft. high. Leaves short-petioled, ovate to ovate-lanceolate, acute or taper-pointed at the apex, finely serrulate, smooth or slightly hairy. Peduncles axillary, slender, 1–3-flowered. Flowers greenish. Capsule 3–5-angled, warty. In low, shady woods.

3. **E. obovatus** Nutt. Running Strawberry Bush. A low shrub, the trailing and rooting branches not usually rising more than 1 or 2 ft. from the ground. Leaves thin, obovate or oblong, mostly tapering to the base. Flowers and fruit nearly as in *E. americanus*. In damp woods.

II. CELASTRUS L.

A woody, twining shrub. Leaves alternate. Flowers diœcious or somewhat monœcious, small, greenish, clustered at the ends of the branches. Pod 3-celled, 3-valved, looking like an orange-colored berry, which on opening shows the scarlet arils of the seeds.

1. **C. scandens** L. Waxwork, Climbing Bittersweet. Climbing 10–15 ft. Leaves ovate-oblong, 2–4 in. long, finely serrate, taper-pointed. In thickets and along fences; also planted for the showy scarlet seeds, which retain their color for many months.

58. STAPHYLEACEÆ. Bladder Nut Family

Shrubs. Leaves pinnately compound, with stipules, and the leaflets with little individual stipules (stipels). Flowers regular and perfect. Calyx lobes 5. Petals 5, inserted in or around a saucer-shaped disk. Stamens 5, alternate with the petals, perigynous. Ovary 2–3-celled, with the carpels more or less distinct; ovules several; styles 2–3, somewhat united below. Fruit usually 1–few-seeded.

STAPHYLEA L.

Calyx deeply 5-parted, the lobes appearing like separate sepals, erect. Petals spatulate, borne on the rim of the thick disk. Pod large, papery, 3-celled, finally opening at the top. Seeds 1–4 in each cell, bony.

1. **S. trifolia** L. American Bladder Nut. A shrub 6–12 ft. high, with smooth, slender, greenish-striped, at length gray, branches. Leaves long-petioled, with 3 ovate, taper-pointed, finely serrate leaflets. Damp thickets.

59. ACERACEÆ. Maple Family

Trees or shrubs, with abundant, often sugary sap. Leaves opposite, simple and palmately lobed, or pinnate, without stipules. Flowers regular, mostly somewhat monœcious or diœcious, in axillary and terminal cymes or racemes. Calyx 4–9-parted. Petals as many as the lobes of the calyx or none. Stamens 4–12, hypogynous. Ovary 2-celled; styles 2. Fruit a double key.*

ACER L.

Characteristics of the genus as above given for the family.

1. **A. saccharum** Marsh. Sugar Maple. A large tree. Leaves simple, palmately lobed, truncate or heart-shaped at the base, lobes sinuate-toothed and acuminate, pale and slightly downy beneath. Flowers appearing with the leaves, on clustered drooping pedicels. Calyx bell-shaped, fringed. Petals none. Keys smooth, wings about

1–1½ in. long. In cold woods, more abundant northward. The sap of this tree is the principal source of maple sugar, and some forms of the tree produce the curled maple and bird's-eye maple used in cabinet making.*

2. A. saccharinum L. WHITE MAPLE, RIVER MAPLE. A tall tree with the main branches slender and rather erect. Leaves very deeply 5-lobed, with the notches rather acute, silvery-white, and when young downy on the lower surface, the divisions narrow, coarsely cut and toothed. Flowers greenish, in umbel-like clusters, appearing long before the leaves. Petals absent. Fruit woolly at first, then smooth, with diverging wings, the whole 2–3 in. long. Common on river banks S. and W., also planted for a shade tree, but not safe, as the branches are easily broken off by the wind.

3. A. rubrum L. RED MAPLE. A small tree with red or purple twigs. Leaves simple, broadly ovate, palmately 3–5-lobed or sometimes merely serrate or cut-toothed, taper-pointed at the apex, rounded or heart-shaped at the base, smooth or downy, becoming bright red in autumn. Flowers appearing before the leaves on erect, clustered pedicels. Petals red or yellow, oblong or linear. Fruiting pedicels elongated and drooping. Key red, smooth, wings about an inch long. Swamps and river banks E.*

4. A. Pseudo-Platanus L. SYCAMORE MAPLE. Easily recognized by its drooping clusters of rather large green flowers, which appear with the leaves. Cultivated from Europe.

5. A. platanoides L. NORWAY MAPLE. A large tree, with milky sap, which exudes from broken shoots or leafstalks in the spring. Cultivated from Europe; a very desirable shade tree.

6. A. Negundo L. BOX ELDER. A small tree. Leaves opposite, pinnately 3–5-foliate; leaflets ovate, lobed, toothed or entire, downy when young. Flowers diœcious, appearing from lateral buds before or with the leaves; the staminate on long and drooping pedicels, the pistillate in drooping racemes. Keys smooth, 1–1½ in. long. River banks. Often cultivated as a quick-growing shade tree.*

60. HIPPOCASTANACEÆ. BUCKEYE FAMILY

Trees or shrubs. Leaves opposite, long-petioled, palmately compound. Flowers showy, somewhat monœcious, in terminal panicles. Calyx 5-lobed, oblique. Petals 4–5, unequal. Stamens 5–8, hypogynous. Pistil 1; ovary 3-celled, 2 ovules in each cell; style slender. Fruit a 1–3-celled, leathery capsule, 1–3-seeded. Seeds with a large scar.*

ÆSCULUS L.

Characteristics of the genus as above given for the family.

1. Æ. Hippocastanum L. HORSE-CHESTNUT. A round-topped tree with frequently forking branches and stumpy twigs. Leaves very large, with 7 straight-veined leaflets. Flowers large and showy. Corolla open and spreading, of 5 white petals, spotted with purple and yellow. Stamens with long, curved filaments. Fruit large, covered with stout, soft prickles when young. Cultivated from Asia.

2. Æ. glabra Willd. OHIO BUCKEYE. A large tree, not unlike a horse-chestnut. Leaflets generally 5. Flowers small. Corolla of 4 upright, pale yellow petals. Stamens curved, about twice as long as the petals. Fruit prickly at first. River banks.

3. Æ. octandra Marsh. SWEET BUCKEYE. Varying in size from a low shrub to a tall tree. Leaves with 5–7 leaflets. Flowers in a short, dense panicle. Petals 4, in 2 unlike pairs, bending inward; blades of the longer pair very small. Fruit not prickly. Woods W. and S.

4. Æ. Pavia L. RED BUCKEYE. Shrubs. Stems erect, branched, 4–8 ft. high. Leaflets usually 5, lanceolate to narrowly oval, taper-pointed at both ends, finely serrate, smooth or nearly so. Flowers in dense, erect panicles, bright red. Stamens rather longer than the petals. Fruit nearly smooth. Common in open woods.*

61. BALSAMINACEÆ. BALSAM FAMILY

Tender, fleshy-stemmed, annual herbs. Leaves simple, without stipules. Flowers bisexual, zygomorphic. Sepals usually 3, the largest one with a spur. Petals 3. Stamens 5, distinct or nearly so. Ovary 5-celled, bursting when ripe into 5 valves.

IMPATIENS L.

Characteristics of the genus those above given for the family. Fruit a capsule (very fleshy in our species), which when ripe bursts open with considerable force, throwing the seeds about.

1. I. pallida Nutt. WILD BALSAM, LADY'S SLIPPER. Stem 3–5 ft. high, branching. Leaves oblong-ovate, 2–6 in. long, the lower often long-petioled, the upper nearly sessile. Peduncles axillary, 1–3 in. long, slender, 2–5-flowered. Flowers pale yellow, slightly dotted with brownish-red. Sac of the large sepal broader than it is long, ending in a recurved spur about ¼ in. long. Damp, shaded ground, not very common.

2. I. biflora Walt. WILD BALSAM, LADY'S SLIPPER, JEWELWEED, SNAPWEED, KICKING COLT. Stem 2–4 ft. high, branching. Leaves rhombic-ovate, 1–4 in. long. Peduncles about 1 in. long, generally 2–3-flowered. Flowers orange color, with many pretty, large, reddish-brown spots. Sac longer than it is broad, ending in a recurved spur about ½ in. long. Damp, shaded ground, commoner than No. 1 and usually blossoming earlier.

62. RHAMNACEÆ. BUCKTHORN FAMILY

Trees or shrubs. Leaves simple, often 3–5-nerved; stipules small. Flowers small, sometimes unisexual, green or yellow. Calyx 4–5-lobed. Petals 4, 5, or absent, inserted on a disk at the throat of the calyx, very small, hooded, usually with claws. Stamens 4–5, inserted with the petals and opposite them, often inclosed by the petals; filaments awl-shaped; anthers small, versatile. Ovary 3-celled, 3-ovuled.

I. BERCHEMIA Neck.

Shrubs; stems twining or erect. Leaves alternate, prominently pinnate-veined, stipules minute. Flowers in axillary or terminal panicles, or rarely solitary. Calyx tube hemispherical, 5-lobed. Petals 5, sessile, concave, as long as the calyx. Ovary 2-celled, half inferior; stigmas 2. Fruit an oval, 2-seeded drupe.*

1. B. scandens Trel. SUPPLE JACK, RATTAN VINE. Woody, often twining high; older bark yellowish, twigs purple, wood very tough. Leaves ovate or oval, acute or obtuse, cuspidate at the apex, rounded at the base, wavy on the margins, green above, pale beneath. Flowers in small panicles. Fruit purple. In moist woods and along streams S.*

II. RHAMNUS L.

Leaves alternate, deciduous. Flowers in small, axillary cymes, often unisexual. Petals 4–5 or wanting. Stamens 4 or 5, very short. Drupe, 2–4-seeded.

1. R. lanceolata Pursh. A tall shrub. Leaves with short petioles, taper-pointed or somewhat obtuse, very variable in size, smooth or nearly so above, more or less downy beneath, finely serrate. Flowers

2 or 3 together in the axils, greenish, about $\frac{1}{8}$ in. in diameter, usually diœcious, appearing at the same time as the leaves. Calyx 4-lobed. Petals 4. Stamens 4. Fruit black, about $\frac{1}{4}$ in. in diameter. Hills and river banks.

2. R. caroliniana Walt. CAROLINA BUCKTHORN. A small tree with black bark and very hard wood; twigs finely downy. Leaves alternate, prominently veined, elliptical to broadly oval, entire or obscurely serrate, smooth or sometimes downy below; petioles slender, downy. Flowers in axillary, peduncled umbels; petals minute. Fruit globose, $\frac{1}{3}$–$\frac{1}{2}$ in. in diameter, 3-seeded. Seeds smooth. On river banks.*

III. CEANOTHUS L.

Shrubs. Leaves alternate, petioled. Flowers bisexual, in terminal panicles or corymbs formed of little umbel-like clusters. Calyx tube top-shaped or hemispherical, with a 5-lobed border. Petals 5, with hoods, on slender claws. Stamens 5; filaments long and thread-like. Fruit dry, 3-lobed, splitting when ripe into 3 carpels.

1. C. americanus L. NEW JERSEY TEA, RED ROOT. Shrub, with many branching stems, 1–3 ft. high, from a deep red root. Leaves 1–3 in. long, ovate or nearly so, acute or taper-pointed at the tip, obtuse or somewhat heart-shaped at the base, downy beneath, serrate, 3-nerved. Flowers small, white.

2. C. ovatus Desf. SMALLER RED ROOT. Similar to *C. americanus* but usually smaller and nearly smooth. Leaves narrowly oval or elliptical-lanceolate, finely glandular-serrate, $\frac{1}{2}$–2 in. long. Dry rocks and prairies, especially S.W.

63. VITACEÆ. VINE FAMILY

Shrubs, with the stem swollen at the insertion of the petioles and climbing by tendrils borne opposite the leaves. Leaves alternate, with stipules simple or compound. Flowers small, greenish, generally in clusters, borne in similar positions to the tendrils, hypogynous or nearly so. Sepals, petals, and stamens 4–5. Carpels 2, each 2-ovuled. Calyx very small. Corolla deciduous, the petals often hooded. Stamens opposite the petals. A disk inside the calyx bears nectar and its lobes alternate with the stamens. Fruit a berry.

I. PSEDERA Neck. (PARTHENOCISSUS)

Woody vines, climbing by tendrils and rootlets. Leaves palmately compound. Flowers in compound cymes, perfect or somewhat monœcious. Petals 5, distinct, spreading; disk none. Stamens 5. Ovary 2-celled, 4-ovuled. Fruit a 1–4-seeded berry, not edible.*

1. **P. quinquefolia** Greene. Woodbine, Virginia Creeper. Stem smooth. Leaflets dull green, paler below; tendrils 5–12-branched, most of the branches ending in disks which cling to supporting objects. Flowers panicled, the main branches of the cluster unequal. Fruit hardly fleshy. Thickets, common.

2. **P. vitacea** Greene. Woodbine, Virginia Creeper. Stem smooth or slightly downy. Leaflets deep green above, not much paler below; tendrils 2–5-branched, the branches usually without disks at the tips. Flower cluster forking regularly, the main branches nearly equal. Fruit more fleshy than in No. 1. Moist woods and thickets in deep, rich soil; common.

3. **P. tricuspidata** Rehder. Japanese Ivy, Boston Ivy. A freely branching, hardy climber. Tendrils numerous, branching with closely adhesive disks. Leaves occasionally with 3 leaflets, but usually with only one, which is jointed with the main petiole and in autumn falls before the petiole; leaflet 3-lobed or only scalloped, roundish-ovate or heart-shaped, rather thick and shining. Cultivated from Japan.

II. VITIS L.

Climbing woody vines. Stems with enlarged joints, climbing by tendrils opposite some of the leaves. Leaves simple, palmately veined or lobed; stipules small, soon deciduous. Flowers mostly somewhat monœcious or diœcious. Petals often united at the apex and not expanding. Stamens inserted between the lobes of the disk. Ovary usually 2-celled, 4-ovuled. Fruit juicy, 1–4-seeded.*

1. **V. labrusca** L. Fox Grape. Stems climbing high, often 1 ft. or more in diameter; bark shreddy, coming off in long strips; young branches woolly. Leaves broadly heart-shaped, more or less deeply 3–5-lobed, mucronate-dentate, very woolly when young, becoming smooth above. Panicles of pistillate flowers compact, of staminate flowers looser. Fruit about ½ in. in diameter, dark purple or sometimes nearly white. In rich woods E., S., and S.W. Many of the cultivated varieties, such as Concord, Niagara, etc., have been developed from this species.*

2. V. æstivalis Michx. SUMMER GRAPE. Stem climbing high; bark shreddy. Leaves broadly heart-shaped, 3–5-lobed, the lobes dentate, notches rounded, white-woolly when young, often nearly smooth when old; tendrils or panicles opposite 2 out of every 3 leaves, panicles long and slender. Fruit dark blue, small, very acid. In rich woods E. and S.*

3. V. cinerea Engelm. DOWNY GRAPE. Branchlets angular, covered with whitish or grayish down. Leaves entire or slightly 3-lobed, with whitish or grayish down, especially on the under side. Berries small, black, without bloom. S.W.

4. V. cordifolia Michx. FROST GRAPE, CHICKEN GRAPE. Leaves rather smooth, thin, and shining, either not lobed or somewhat 3-lobed, heart-shaped, with the notch at the base deep and acute, taper-pointed, with large, sharp teeth. Flower clusters large and loose. Grapes shining black, very sour, not ripening until after frosts; seeds 1 or 2, rather large. Moist thickets and banks of streams S.

5. V. vulpina L. RIVERSIDE OR SWEET-SCENTED GRAPE. Resembling *V. cordifolia*, but the leaves more shining and more commonly 3-lobed. Fruit bluish-black, with a bloom, moderately sweet, $\frac{1}{3}$ in. or more in diameter, beginning to ripen in July. Along ponds and streams, especially W. and S.W.

6. V. rotundifolia Michx. MUSCADINE GRAPE. Stem climbing high; joints short; bark not shreddy; wood very hard, often producing long, aërial roots. Leaves orbicular, heart-shaped at the base, coarsely toothed, nearly or quite smooth. Panicle small. Grapes few in a cluster, large. The original form of the Scuppernong grape. S.*

64. TILIACEÆ. LINDEN FAMILY

Trees or shrubs, rarely herbs. Leaves alternate, with stipules. Flowers bisexual in cymes, the latter usually in corymbs or panicles. Sepals 5. Petals 5 or fewer, or wanting. Stamens many, inserted on a swollen disk. Ovary 2–10-celled, with one or more ovules in each cell. Fruit 1–12-celled, dry or berry-like.

TILIA L.

Trees with rough gray bark on the trunk; bark of the twigs smooth, lead-colored; wood white and soft. Leaves cordate, usually inequilateral. Cymes axillary or terminal, peduncles adnate to a large, prominently veined, leaf-like bract. Flowers yellowish-white. Sepals 5. Petals 5. Stamens many, in 5 groups. Ovary 5-celled, with 2 ovules in each cell; stigma 5-lobed. Capsule 1-celled, 1–2-seeded; peduncle and bract deciduous with the matured fruit, the bract forming a wing by which the fruit is often carried to a considerable distance.*

1. T. americana L. BASSWOOD, WHITEWOOD. A large tree, sometimes 125 ft. high. Leaves larger than in No. 2 (2–5 in. wide), often unsymmetrical, heart-shaped or truncate at the base, sharply toothed. Floral bract often narrowed at the base. Fruit somewhat ovoid, $\frac{1}{3}$ in. or more in diameter. Common in rich woods; occurs farther N. than No. 2.

2. T. Michauxii Nutt. BASSWOOD. A tree of medium size. Leaves ovate, acuminate at the apex, obtuse and oblique at the base, mucronate-serrate, woolly on both sides or smooth above when old. Flowers fragrant; floral bract 2–3 in. long, usually rounded at the base. Fruit globose, about $\frac{1}{4}$ in. in diameter. In rich woods. Bees gather large quantities of nectar from the flowers.*

3. T. heterophylla Vent. WHITE BASSWOOD. A large tree. Leaves larger than in *T. americana* or *T. Michauxii*, often 6–8 in. long, smooth and bright green above, silvery-downy underneath. In wooded or mountainous districts.

4. T. europæa L. EUROPEAN LINDEN. A good-sized tree. Leaves roundish, obliquely heart-shaped, abruptly taper-pointed, finely toothed. Flowers differing from Nos. 1 and 2 in the absence of petal-like scales at the bases of the stamens. Cultivated from Europe.

65. MALVACEÆ. MALLOW FAMILY

Herbs or shrubs, with simple, alternate, palmately-veined leaves, with stipules. Flowers actinomorphic. Sepals 5, often surrounded by an involucre at the base. Petals 5. Stamens numerous, monadelphous. Pistils several, more or less distinct. Fruit a several-celled capsule or a collection of 1-seeded carpels.

I. ABUTILON Adans.

Calyx 5-cleft, the tube often angled. Styles 5–20, with knobbed stigmas. Carpels as many as the styles, arranged in a circle, each 1-celled, 3–6-seeded, and opening when ripe by 2 valves.

1. A. striatum Dicks. TASSEL TREE, FLOWERING MAPLE. A shrub 5–10 ft. high. Leaves maple-like. Flowers showy, solitary, nodding on slender peduncles. Corolla not opening widely, orange, striped with reddish-brown veins. Column of stamens projecting beyond the corolla like a tassel. Cultivated in hothouses. From Brazil.

II. MALVASTRUM Gray

Calyx with an involucel of 2 or 3 bractlets or none. Petals notched at the end or entire. Styles 5 or more, with knobbed stigmas. Carpels not splitting open or somewhat 2-valved, falling from the axis when mature, tipped with a point or beak.

1. **M. coccineum** Gray. Red False Mallow. Perennial, 4–10 in. high, covered with a dense silvery down of star-shaped hairs. Leaves 3–5-parted. Flowers in short spikes or racemes. Petals red, much longer than the calyx. Carpels 10 or more, with a wrinkled network on the sides. Prairies W. and S.W.

III. MALVA L.

Calyx 5-cleft, with a small, 3-leaved involucel. Petals obcordate or truncate. Styles many, slender, with stigmas running down the sides. Carpels many, 1-seeded, arranged in a circle and separating from each other, but not opening when ripe.

1. **M. rotundifolia** L. Common Mallow, Cheeses (from appearance of the unripe fruit). A common biennial or perennial weed, with nearly prostrate stems. Leaves long-petioled, round-kidney-shaped, with crenate margins. Flowers small, whitish, on long peduncles.

2. **M. sylvestris** L. High Mallow. Biennial or perennial. Stem erect, 2–3 ft. high. Leaves 5–7-lobed. Flowers purplish, larger than those of the preceding species.

IV. CALLIRHOË Nutt.

Calyx naked, or with a 3-leaved involucel at the base. Petals wedge-shaped, often toothed and fringed. Styles and stigmas as in *Malva*. Carpels 10–20, joined in a circle, 1-seeded, beaked at the tip.

1. **C. alcæoides** Gray. Light Poppy Mallow. Perennial. Stems rather slender, 8–20 in. high, covered with close-lying stiff hairs. Basal leaves triangular-heart-shaped, palmately lobed or incised;

stem leaves palmately divided. Involucel none. Flowers pink or white, about 1 in. in diameter. Carpels strongly wrinkled. In dry soil W. and S.W.

2. C. digitata Nutt. FRINGED POPPY MALLOW. Resembling *C. alcæoides*. Flowers $1\frac{1}{2}$–2 in. in diameter. Petals reddish-purple to white, fringed. In dry soil S.W.

3. C. involucrata Gray. PURPLE POPPY MALLOW. Perennial. Stems 1–2 ft. high, procumbent or ascending. Leaves round-heart-shaped, palmately lobed or cut. Involucel 3-leaved. Peduncles long, slender, and 1-flowered. Flowers reddish-purple, 1–$2\frac{1}{2}$ in. in diameter. Carpels with a wrinkled network. In dry soil W. and S.W.

66. HYPERICACEÆ. ST. JOHN'S-WORT FAMILY

Herbs, shrubs, or trees. Leaves opposite, often covered with translucent or dark dots, entire or with glandular teeth, without stipules. Flowers usually in terminal cymes. Sepals 5, rarely 4. Petals as many as the sepals, hypogynous. Stamens usually many, more or less grouped in bundles; anthers versatile. Pod 1-celled, with 2–5 parietal placentæ and the same number of styles, or else 3–7-celled, splitting along the partitions.

HYPERICUM L.

Herbs, shrubs, or small trees. Leaves sessile, often dotted. Flowers yellow, bisexual.

B. Fl. species 2 (*Sarothra*).

1. H. perforatum L. COMMON ST. JOHN'S-WORT. Perennial. Stem erect, 1–3 ft. high, 2-ridged, much branched. Leaves linear or oblong, obtuse, with translucent veins and dots. Cymes grouped in corymbs, many-flowered. Flowers 1 in. in diameter. Sepals acute. Petals much longer than the sepals, oblique at the tip and irregularly fringed. A common weed in meadows and pastures E. and N. Naturalized from Europe.

2. H. gentianoides BSP. ORANGE GRASS, PINEWEED. Low (4–9 in. high), slender annual, with erect, angled or almost winged, wiry stem and branches. Leaves minute awl-shaped scales. Corolla about $\frac{1}{4}$ in. in diameter, usually closing by or before midday. Sandy banks and roadsides.

67. VIOLACEÆ. Violet Family

Herbs, with simple, alternate leaves, with stipules. Calyx of 5 persistent sepals. Corolla of 5 petals, somewhat zygomorphic; one petal with a spur. Stamens 5, short, the filaments often united around the pistil (Fig. 24). Style generally club-shaped, with a one-sided stigma, with an opening leading to its interior. Pod 1-celled, splitting into 3 valves, each bearing a placenta. The seeds are often dispersed by the splitting of the elastic valves (Fig. 24).

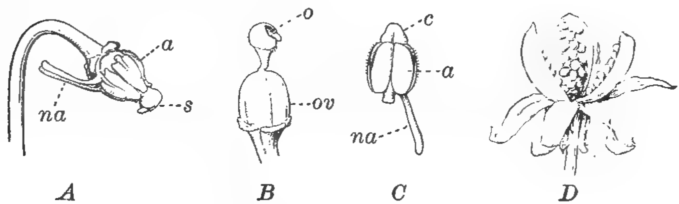


Fig. 24. *Viola tricolor*

A, stamens and pistil; *B*, pistil with stamens removed; *C*, stamen; *D*, pod split open. *a*, anther; *c*, connective; *na*, nectarial appendage of stamen; *o*, orifice in stigma; *ov*, ovary; *s*, stigma. (*A*, *B*, and *C* considerably magnified)

VIOLA L.

Sepals ear-like at the base. Some of the petals often bearded within, thus affording a foothold for bees, the lowest one with a spur at the base. Stamens not very much united, the two lowermost with spurs which reach down into the spur of the lowest petal. Many species bear inconspicuous apetalous flowers later than the showy ordinary ones, and produce most of their seed from these closed, self-fertilized flowers.

§ 1. *Apparently stemless perennials*

1. V. pedata L. Bird-Foot Violet, Horseshoe Violet, Sand Violet. Rootstock stout, upright, not scaly. Leaves roundish, all palmately 5–9-parted into linear or linear-lanceolate divisions. Flowers showy, about 1 in. broad, pale violet to whitish; petals not bearded. Dry fields and hillsides.

2. V. cucullata Ait. MARSH BLUE VIOLET. Leaves acute, except the earliest ones. Petal-bearing flowers violet blue, with a darker center; peduncles usually longer than the leaves, the spur-bearing petal smooth. Sepals narrowly lanceolate, with long ear-like appendages. Cleistogamous flowers borne on erect or ascending peduncles. Capsule not much longer than the sepals. Wet ground, common.

3. V. papilionacea Pursh. COMMON BLUE VIOLET, DOORYARD VIOLET. Plants usually strong and vigorous from a thick horizontal rootstock, usually smooth. Leaves bright green, cordate at the base, somewhat triangular or rounded and pointed. Scapes at the time of flowering longer than the leaves. Petals dark violet-purple, white or greenish-yellow at the base, the one with a spur often narrow and boat-shaped. Capsules from the cleistogamous flowers borne on horizontal peduncles and often underground, but rising as they mature. Very common about dwellings and gardens.

4. V. palmata L. EARLY BLUE VIOLET. Usually downy. Petioles much longer than the blades; leaves, except the earliest ones, cordate-ovate, with 5–9 variously toothed or cleft segments; the petioles and the veins of the under surface very hairy. Scapes not usually longer than the leaves. Sepals lanceolate, acute or taper-pointed. Petals violet-purple, occasionally pale. Capsules from the cleistogamous flowers borne on horizontal or deflexed peduncles. In dry, rich woodlands.

5. V. sororia Willd. WOOLLY BLUE VIOLET. In size and appearance much like No. 3. Leaves ascending, mostly ovate or roundish-ovate, pointed, cordate at the base, crenate, densely soft-hairy when young. Peduncles hairy; petals varying from violet to lavender. Cleistogamous flowers on short prostrate peduncles. Moist meadows and rich woods.

6. V. fimbriatula Sm. OVATE-LEAVED VIOLET. Rootstock usually erect, at length long and stout. Petioles generally shorter than the blades; leaves varying from ovate-lanceolate to oblong, usually slightly crenate, truncate or almost cordate at the base. Petals blue, bearded. Capsules of the cleistogamous flowers borne on erect peduncles. In dry woods.

§ 2. *Leafy-stemmed perennials*

7. V. pubescens Ait. DOWNY YELLOW VIOLET. Soft-downy, 6–12 in. high. Basal leaves ovate-kidney-shaped, soon withering; stem leaves broadly heart-shaped, toothed, pointed, with large stipules. Flowers yellow, somewhat purple-veined, with a short spur. In dry woods, common.

8. V. scabriuscula Schwein. SMOOTHISH YELLOW VIOLET. Like *V. pubescens*, but smaller, greener, and less downy. Stems decumbent or ascending. Basal leaves broadly ovate, usually persistent through the flowering period. Flowers pale yellow, purple-veined. In moist woods and thickets.

9. V. canadensis L. CANADA VIOLET. Stems tufted, very leafy, smooth, 1 ft. or more high. Leaves heart-shaped, acute or taper-pointed, serrate; stipules lanceolate, entire. Flowers large and handsome. Petals white or nearly so, inside, the upper ones usually violet-tinged beneath; lateral petals bearded. In rich woods, especially of hilly regions.

10. V. striata Ait. STRIPED VIOLET. Similar to *V. canadensis*, but the stipules dentate, pinnately cut, or fringed. Petals cream-colored, white, or bluish, distinctly veined. Moist woods and thickets.

§ 3. *Leafy-stemmed, from an annual, biennial, or occasionally short-lived perennial root; stipules about as large as the blades of the leaves.*

11. V. tricolor L. PANSY, HEART'S-EASE. Stem branching, angular, hardly erect. Leaves variable, more or less ovate, crenate or crenate-serrate. Flowers large (often more than 1 in. across), flattish, short-spurred, exceedingly variable in color. Cultivated from Europe.

12. V. arvensis Murr. FIELD PANSY. Similar to *V. tricolor*, but the whole plant smaller and more slender. Leaves narrow, often lanceolate, the stipules dissected into narrow divisions. Petals all yellow, equaling or shorter than the slender, pointed sepals. Common in old fields. Naturalized from Europe.

13. V. Rafinesquii Greene. WILD PANSY. Annual, slender, often branching from the base. Leaves small, the earlier ones roundish, on slender petioles; the later ones obovate or narrower, tapering to the base. Flowers small, yellowish-white to bluish-white. Petals much longer than the linear sepals. Woods and fields.

68. PASSIFLORACEÆ. PASSION FLOWER FAMILY

Shrubs or herbs, climbing by axillary tendrils. Leaves alternate, simple, mostly 3-lobed. Flowers axillary, on jointed peduncles, solitary or few together, bisexual, actinomorphic, often showy. Calyx tube 4–5-lobed, persistent. Petals usually 5, inserted on the throat of the calyx tube, which is fringed with a crown of 1–3 rows of long and slender filaments. Stamens 5, their filaments united, and inclosing the stalk of the ovary. Styles 1–5; ovary with 3–5 parietal placentæ. Seeds numerous; fruit fleshy.

PASSIFLORA L.

Characters of the family.

1. P. incarnata L. Passion Flower. Perennial. Stem often 20–30 ft. long, somewhat angled or striate, smooth below, downy above. Leaves broadly heart-shaped, palmately 3–5-lobed; the lobes acute, finely serrate, usually heart-shaped at the base; petiole bearing 2 oval glands near its summit. Flowers 2–3 in. wide, solitary; peduncles 3-bracted, longer than the petioles; calyx lobes with a small horn-like appendage on the back near the apex, white within. Petals and crown purple and white. Fruit yellow, about the size and shape of a hen's egg, edible. Seeds with a pulpy aril. Common along fence rows and embankments S.*

2. P. lutea L. Yellow Passion Flower. Perennial. Stem slender, smooth, 6–10 ft. long. Leaves broadly heart-shaped, 3-lobed at the summit, entire, often mucronate; stipules small; petioles without glands. Peduncles longer than the leaves, usually in pairs. Flowers greenish-yellow, $\frac{1}{2}$–$\frac{3}{4}$ in. wide. Fruit purple, oval, $\frac{1}{2}$ in. long. Woods and thickets S.*

69. BEGONIACEÆ. Begonia Family

Chiefly perennial herbs or low shrubs, with fleshy or very juicy stems. Leaves alternate, generally heart-shaped at the base, often very unsymmetrical; stipules deciduous. Flowers monœcious, in cymes or other clusters, on axillary peduncles. Stamens many (Fig. 25). Pistillate flowers with the floral envelopes borne on the ovary. Ovary 3-angled or 3-winged (Fig. 25), very many-seeded.

BEGONIA L.

Flowers with the calyx and corolla of the same color, staminate and pistillate ones both occurring in the same cluster. Sepals usually 2. Petals 2 or in the fertile flowers 3 or 4, sometimes wanting. Stamens many in a cluster, with short filaments. Styles of the fertile flowers 3, often with long, twisted stigmas (Fig. 25, *C*). The genus contains a great number of species and varieties, cultivated from tropical or subtropical regions, of which only a few of the commonest are here described.

1. B. Rex Putz. Herb, apparently stemless or nearly so, from a fleshy rootstock. Leaves large, taper-pointed, very unequally heart-shaped; the margin sinuous, often bristly-fringed; upper surface wholly silvery, or mottled silvery and dark green; lower surface green or reddish, or of both colors. Flowers few, large ($1\frac{1}{2}$–$1\frac{3}{4}$ in. in diameter), varying from yellow to pinkish. Cultivated from the Himalayas. Many varieties.

2. B. manicata Brongn. Herb, with a short and fleshy stem. Leaves very unevenly heart-shaped, taper-pointed; the margins bristly-fringed and sometimes with very remote teeth; upper sur-

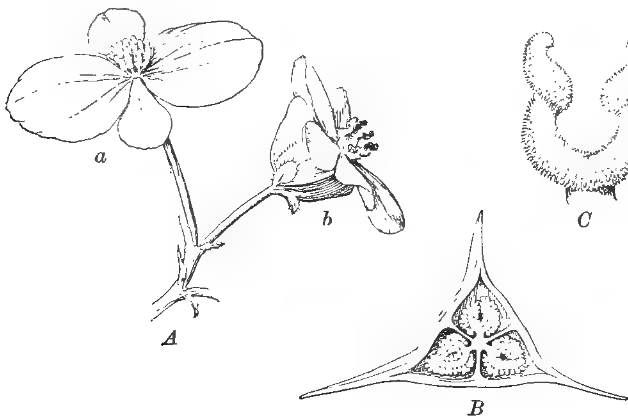


FIG. 25. Begonia flowers

A: *a*, staminate flower; *b*, pistillate flower. *B*, cross section of ovary; *C*, twisted stigmas, enlarged

face dark green, lower surface and petioles partly covered with long fringed scales; stipules larger and fringed. Flowers flesh-colored, handsome, in a loose panicle borne on a long peduncle. Cultivated from Mexico.

3. B. coccinea Hook. Tall, 3–10 ft. high, somewhat shrubby, often with many erect, smooth stems from the same root. Leaves broadly and unevenly lanceolate or ovate-lanceolate, half heart-shaped or broadly one-eared at the base, acute, nearly or quite entire, smooth, dull green above, sometimes tinged with red below. Peduncles several–many-flowered, reddish, slender, somewhat nodding. Flowers showy, medium-sized, scarlet. Fruit showy, scarlet, very broadly winged. Cultivated from Peru. [Often called *B. rubra*.]

4. **B. incarnata** L. & O. Herbaceous or mainly so, rather tall (2–4 ft.), stems clustered, slightly reclining, hairy when young, at length smoother. Leaves broadly and very unequally ovate-lanceolate, tapering toward the tip but at the extremity somewhat blunt, half heart-shaped at the base, somewhat lobed and sinuate-toothed, rough-hairy above and below and on the petioles, dark green above with coppery streaks along the veins. Flowers on short peduncles, few, of medium size; beautiful rose-pink in the bud, becoming almost white; thickly covered outside with soft, moss-like hairs. Cultivated from Mexico. [Often called *B. metallica.*]

5. **B. semperflorens** L. & O. Stems smooth, herbaceous, rather fleshy, branching near the ground and reclining. Leaves obtuse or nearly so, broadly ovate, somewhat unevenly heart-shaped or tapering at the base, irregularly serrate or scalloped and wavy, smooth, dark green, and very glossy above; stipules rather large, nearly ovate. Flowers in small, axillary clusters near the top of the stem; whitish to crimson, about $1\frac{1}{4}$ in. in diameter. Ovary in fruit very broadly winged. An easily grown but homely species. Cultivated from S. Brazil.

70. CACTACEÆ. Cactus Family

Plants usually with very fleshy and much thickened, often globular or cylindrical, stems. Leaves usually wanting. Flowers sessile, solitary, often very showy. Perianth epigynous, consisting of several rows of sepals and petals. Stamens many, with slender filaments, borne on the inside of the perianth tube. Style 1; stigmas numerous; ovary 1-celled, many-ovuled. Fruit a many-seeded berry.

I. OPUNTIA L.

Stem composed of a series of flattened joints, which are usually leafless when full grown. Leaves very small, awl-shaped, spirally arranged, appearing on the young joints but soon dropping off, with barbed bristles and sometimes spines in their axils. Flowers yellow. Sepals and petals not much united into a tube. Fruit often eatable.

1. **O. vulgaris** Mill. Common Prickly Pear. Prostrate or nearly so, pale green. Leaves about $\frac{1}{6}$ in. long, rather scale-like; bristles many, with few or no spines. Flowers 2 in. or more in diameter,

with about 8 petals. Fruit about 1 in. long, crimson when ripe, eatable. Dry rocks and sandy ground, from Massachusetts south along the coast.

2. O. Rafinesquii Engelm. Prostrate, green. Leaves $\frac{1}{4}$–$\frac{1}{3}$ in. long, awl-shaped, spreading; bristles often intermixed with a few small spines and a larger one $\frac{3}{4}$–1 in. long. Flowers larger than in No. 1 and with 10–12 petals. Fruit about $1\frac{1}{2}$ in. long, much tapered at the base. In poor soil.

3. O. polyacantha Haw. Prostrate, light green. Leaves very small, with bristles and 5–10 spines in their axils. Flowers 2–3 in. in diameter. Fruit dry and spiny. Wisconsin, S. and W.

II. PHYLLOCACTUS Link.

Stems cylindrical when old, with long, flattened, fleshy but leaf-like, sinuate or serrate branches. Flowers nearly or quite regular, from the notches in the margins of the joints.

1. P. Ackermanni Solm. D. Flowers very showy, bright red. Perianth tube shorter than the petals. Sepals scattered, small and bract-like. Petals many, 2–3 in. long, widely spreading, somewhat channeled, sharp-pointed. Cultivated from Mexico.

III. CEREUS L.

Stem more or less prismatic but strongly ridged, with bundles of spines borne on the ridges; sometimes prostrate or trailing, sometimes erect, columnar, and 50 or 60 ft. high. Flowers usually showy, borne on the sides of the stem, generally with a rather long perianth tube, which is covered outside with scale-like sepals, usually with tufts of wool in their axils. Petals many, mostly long and spreading.

1. C. speciosus K. Sch. Stems 2–3 ft. high, with 3–4 broad-winged and sinuate ridges. Flowers open in the daytime and lasting several days, red or crimson, very showy. Petals longer than the tube, stamens white, drooping, very numerous. Commonly cultivated from Mexico.

2. C. grandiflorus Mill. NIGHT-BLOOMING CEREUS. Stems long, climbing by aërial roots, nearly cylindrical, but with 5 or more blunt angles. Flowers very showy, opening only for one night, wilting early in the morning, extremely fragrant. Sepals dull yellow. Petals pearly white, spreading, 6–8 in. long. Cultivated from Mexico.

71. ONAGRACEÆ. Evening Primrose Family

Herbs, rarely shrubs or trees. Leaves opposite or alternate, without stipules. Flowers actinomorphic. Limb of the calyx epigynous, 2–4-lobed. Petals 2–4, rarely wanting, quickly falling off. Stamens 1–8. Ovary usually 4-celled; style thread-like; stigma entire or 4-lobed; ovules 1 or more in the inner angle of each cell. Fruit a capsule, berry, or drupe. Seeds 1 or more, smooth or hairy.

I. ŒNOTHERA L.

Herbs, rarely shrubby. Leaves alternate. Flowers large, yellow, red, or purple. Calyx tube 4-angled. Petals 4. Stamens 8. Capsule usually 4-celled, many-seeded.

B. Fl. species 1 (*Onagra*); species 2, 3 (*Kneiffia*); species 4 (*Hartmannia*); species 5 (*Megapterium*).

1. Œ. biennis L. Common Evening Primrose. Annual or biennial. Erect and usually stout, 1–5 ft. high, stem usually simple, more or less downy and hairy. Leaves lanceolate, acute or taper-pointed, sessile or the lower ones petioled. Flowers bright yellow, 1–2 in. in diameter, opening in the evening. Pod oblong, narrowed above, erect, nearly cylindrical. In dry soil.

2. Œ. pumila L. Small Sundrops. Perennial. Stem erect, finely downy, 4–24 in. high. Leaves usually smooth, entire, obtuse or nearly so, the basal ones spatulate, those of the stem varying from oblanceolate to lanceolate. Spikes loose, nodding when young. Flowers $\frac{1}{3}$–1 in. in diameter. Pods slightly glandular-downy, club-shaped, $\frac{1}{4}$–$\frac{1}{2}$ in. long. In dry soil.

3. Œ. fruticosa L. Sundrops. Biennial or perennial. Stem erect, often rather stout, 1–3 ft. high, downy or sometimes smooth. Leaves lance-oblong, or in one variety linear or nearly so, usually minutely toothed. Racemes often corymbed. Flowers open in the daytime, showy, yellow, 1–2 in. in diameter. Pod nearly sessile, ellipsoidal, with prominent ribs and strong wings. Dry soil, common.

4. Œ. speciosa Nutt. Showy Primrose. Perennial. Stem downy, erect or somewhat decumbent, 6 in.–3 ft. high. Leaves broadly lanceolate to linear, sinuate-denticulate or sinuate-pinnatifid, 2–3 in. long. Flowers opening in the daytime, few, $1\frac{1}{2}$–$3\frac{1}{2}$ in. in diameter, white to pale pink. Pod strongly 8-ribbed. Prairies S.W.

5. **Œ. missouriensis** Sims. Perennial. Stems low, decumbent, with short, silky down. Leaves thick, from oval to linear, usually lanceolate, narrowed to a slender petiole, 2–6 in. long, entire or remotely toothed. Flowers axillary, yellow, 3–6 in. in diameter. Capsule orbicular, with broad wings. In dry soil S.W.

II. FUCHSIA L.

Herbs, shrubs, or trees. Leaves opposite or 3 in a whorl. Flowers showy. Calyx colored, tubular-funnel-shaped, the tube extending much beyond the ovary, the margin 4-lobed. Petals 4, borne in the throat of the calyx. Stamens 8, projecting outside the corolla. Capsule berry-like, ellipsoidal, 4-angled.

1. **F. macrostemma** R. & P. COMMON FUCHSIA, LADIES' EARDROPS. Smooth. Leaves slender-petioled, toothed. Flowers on long, drooping peduncles from the axils of the leaves. Calyx tube oblong or a short cylinder, not as long as its spreading lobes. Petals obovate and notched, wrapped spirally around the projecting filaments and style. Found in many varieties, sometimes the calyx white or nearly so and the petals dark or with dark calyx and light petals. Cultivated from Chile.

III. CIRCÆA L.

Slender, erect herbs, with creeping rootstocks. Stem simple. Leaves opposite, petioled. Flowers small, in terminal and lateral racemes. Calyx tube ovoid, the limb 2-parted, reflexed, deciduous. Petals 2, inversely heart-shaped, inserted with the 2 stamens under the margin of a disk which is borne on the pistil. Ovary 1–2-celled; style thread-like; stigma knobbed, 2-lobed; ovules, 1 in each cell. Fruit ovoid, not splitting open, covered with hooked bristles.

1. **C. lutetiana** L. ENCHANTER'S NIGHTSHADE. Stem 1–2 ft. high, glandular-downy. Leaves ovate, faintly toothed, long-petioled. Flowers $\frac{1}{8}$ in. in diameter, white or pink, on slender pedicels, jointed at the base. Damp, shaded places; very common.

72. ARALIACEÆ. GINSENG FAMILY

Herbs, shrubs, or trees. Leaves alternate, simple or compound; stipules united to the petiole or wanting. Flowers regular, in umbels or heads. Limb of the calyx epigynous, very short. Petals 5, very deciduous. Stamens 5, filaments bent inward, anthers versatile. Ovary 2-celled or several-celled; styles or stigmas as many as the cells; ovules 1 in each cell. Fruit a drupe or berry. [The English ivy, an important member of the family, flowers too late for school study.]

ARALIA L.

Perennial plants, with pungent or spicy roots, bark, and fruit. Leaves once or more compound. Flowers more or less monœcious, white or greenish, in umbels. Drupe, berry-like.

1. **A. hispida** Vent. BRISTLY SARSAPARILLA, WILD ELDER. Stem 1–2 ft. high, rather shrubby below, with prickly bristles. Leaves once or twice pinnate; leaflets ovate, acute, cut-serrate, and often lobed. Peduncle bearing several umbels of cream-colored flowers, in a terminal corymb. Fruit blue-black. Dry fields and pastures E.

2. **A. nudicaulis** L. WILD SARSAPARILLA. Perennial herb. Roots very long, somewhat fleshy, aromatic; stem very short or none. Leaf solitary, from a sheathing base, petioled, 6–12 in. long; compound in threes, each division 3–5-pinnate; leaflets oval or ovate, taper-pointed, finely and sharply serrate, smooth above, often downy below. Scape nearly as long as the petiole, usually bearing 3 short, peduncled umbels. Flowers greenish. Styles distinct. Fruit globose, black. In rich woods.

73. UMBELLIFERÆ. PARSLEY FAMILY

Herbs, usually with hollow, grooved stems. Flowers small, generally in umbels. Limb of the calyx either wanting or present only as a 5-toothed rim or margin around the top of the ovary. Petals 5. Stamens 5, inserted on the disk, which is borne by the ovary (Fig. 26). Ovary 2-celled and 2-ovuled (Fig. 26), ripening into 2 akene-like carpels, which separate from each other. Each carpel bears 5 longitudinal ribs, in the furrows between which secondary ribs frequently occur. On a cross section of the fruit oil tubes are seen, traversing the interspaces between the ribs, and near the surface of the fruit (Fig. 26, *D*). The seeds contain a small embryo, inclosed in considerable endosperm. [The family is a difficult one, since the flowers are so much alike that the species are distinguished from each other mainly by minute characteristics of the fruit.]

I. ERYNGIUM L.

Annual, biennial, or perennial herbs. Stems erect or creeping. Leaves simple, mostly linear and spiny-toothed. Flowers white or blue, in dense, bracted heads or spikes, flowers bracteolate. Calyx teeth rigid, persistent. Petals erect, pointed. Styles slender. Fruit top-shaped, scaly or granular; ribs wanting; oil tubes usually 5, minute.*

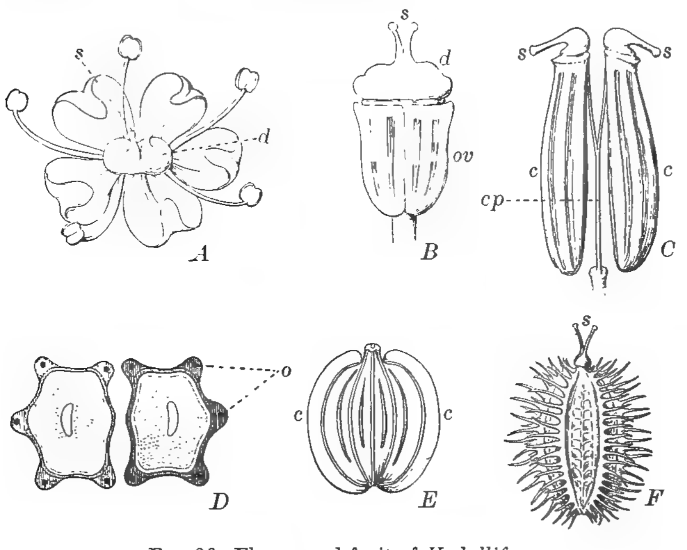


FIG. 26. Flower and fruit of *Umbelliferæ*

A–D, *Carum Carvi*: *A*, flower; *B*, partly matured pistil; *C*, mature fruit; *D*, cross section of fruit. *E*, fruit of parsnip; *F*, fruit of carrot. *c*, carpels; *cp*, carpophore, or stalk to which ripe carpels are attached; *d*, disk; *o*, oil tubes; *ov*, ovary; *s*, stigmas. (*A–D*, after Schnizlein; *E*, after Bischoff)

1. **E. yuccifolium** Michx. BUTTON SNAKEROOT, RATTLESNAKE MASTER. Perennial. Stem erect, branched above, striate, covered with a bloom, 2–3 ft. high. Leaves linear, often 2 ft. or more in

length, rigid, covered with a bloom, parallel-veined, fringed with white bristles. Bracts shorter than the heads, entire; bractlets similar but smaller. Flowers white. Fruit scaly. In damp soil.*

II. SANICULA L.

Slender, erect, perennial herbs. Rootstock short, stout, creeping. Leaves palmately cut. Umbels small, somewhat globular, irregularly compound; bracts leafy; bractlets few; flowers bisexual or staminate, greenish or yellowish. Calyx teeth as long as the small petals, sharp-pointed. Fruit ovoid, covered with hooked prickles, ribless, each carpel with 5 oil tubes.

1. **S. marilandica** L. Sanicle, Black Snakeroot. Perennial. Stem rather stout, 1–4 ft. high. Leaves 3–7-parted, the divisions irregularly serrate or dentate and often cut. Flowers bisexual and staminate, the latter in separate heads. Petals greenish-white, very small. Styles slender, recurved, and longer than the prickles of the fruit. Rich woods.

2. **S. gregaria** Bicknell. Clustered Snakeroot. Stems generally clustered, 1–3 ft. high. Leaves 5-divided, obovate-wedge-shaped to lanceolate. Some of the staminate flowers in separate heads. Petals yellow, much longer than the calyx. Styles longer than the prickles of the fruit. Woods and thickets.

3. **S. canadensis** L. Short-Styled Snakeroot. Leaves petioled, 3–5-divided. Staminate flowers never in separate heads. Styles shorter than the prickles of the fruit. In woodlands.

III. ERIGENIA Nutt.

A little smooth plant, with a slender, unbranched stem, from a deep, nearly globular tuber. Leaves 1 or 2, twice or thrice compound in threes. Flowers few, small, in an imperfect leafy-bracted umbel. Calyx teeth wanting. Petals obovate or spatulate. Fruit smooth, roundish, notched at both ends, the two carpels touching only at top and bottom, each with 5 slender ribs.

1. **E. bulbosa** Nutt. Harbinger of Spring, Turkey Pea, Pepper-and-Salt. Stem scape-like, with a leaf which forms an involucre to the flower cluster. Petals white, anthers brown-purple. A pretty, though inconspicuous plant; welcomed as one of the earliest spring flowers S.

IV. OSMORHIZA Raf. (WASHINGTONIA)

Perennials, springing from stout, aromatic roots. Leaves compound in threes. Flowers white, in compound umbels. Calyx teeth wanting. Fruit linear or nearly so, tapering at the base, with 5 equal bristly ribs, without oil tubes.

1. O. Claytoni Clarke. HAIRY SWEET CICELY. Rather stout and hairy, especially when young, 1½–3 ft. high. Lower leaves on long petioles, large, twice compound in threes, the divisions ovate or oval, cut-toothed; upper leaves nearly sessile, less compound. Umbels with long peduncles and spreading rays. Style and its enlarged base somewhat conical. Root nauseous. Rich woods.

2. O. longistylis DC. SMOOTH-LEAVED SWEET CICELY. Much like No. 1 in general appearance. Smooth or nearly so. Style rather thread-like. Root of a pleasant aromatic flavor (as is also the fruit). Woods.

Caution. So many plants of this family have actively poisonous roots and foliage that it is unsafe for any one but a botanist, who can distinguish the poisonous species from the harmless ones, to taste them.

V. CARUM L.

Herbs, with slender, smooth stems. Leaves pinnately compound, smooth. Umbels compound. Flowers white or yellowish. Calyx teeth minute. Fruit smooth, oblong or ovate, with thread-like ribs; oil tube single in the intervals between the ribs; base of the styles thickened into a conical mass.

1. C. Carvi L. CARAWAY. Perennial. Leaves large, with the leaflets cut into numerous thread-like divisions. Flowers white. Fruit aromatic, used somewhat in this country and more in N. Europe for flavoring cookies, bread, etc. Introduced from Europe.

VI. ZIZIA Koch.

Smooth perennials. Leaves generally as in *Thaspium.* Involucre wanting; involucels of small bractlets. Umbels compound. Flowers yellow. Calyx teeth prominent. Fruit more or less ovoid, smooth, with thread-like ribs; oil tubes large and solitary between the ribs, and a little one in each rib; the central fruit of each umbellet sessile.

1. **Z. aurea** Koch. MEADOW PARSNIP, GOLDEN ALEXANDERS. Smooth, stem erect, 1–2 ft. high. Basal leaves mostly heart-shaped and serrate; stem leaves usually once compound in threes. Flowers deep yellow. Fruit between globose and ovoid, about $\frac{1}{6}$ in. long; all the ribs generally winged. Woods and thickets.

VII. THASPIUM Nutt.

Perennial herbs. Stem erect. Leaves 1–2, compound in threes. Umbels compound; involucre and involucels usually wanting. Flowers yellow or purple. Calyx teeth small, acute. Fruit ovoid or oblong, somewhat laterally compressed; carpels smooth, strongly ribbed; oil tubes between the ribs.*

1. **T. barbinode** Nutt. HAIRY MEADOW PARSNIP. Stem erect, branching above, downy at the nodes, 2–7 ft. high. Leaves petioled, slightly downy; leaflets mostly thin, ovate, toothed, incised or lobed toward the apex, entire toward the base. Umbels long-peduncled, few-rayed. Fruit oblong; lateral and central ribs strongly winged. Along streams.*

VIII. LOMATIUM Raf.

Perennial herbs, appearing stemless. Roots thickened. Leaves dissected. Flowers white or yellow, in compound umbels, with no general involucre. Calyx teeth usually wanting. Fruit orbicular, oval or oblong, much flattened dorsally, the lateral ribs extended into broad wings; oil tubes 1–4 on the intervals between wings and 2–6 on the junctions of the carpels.

1. **L. orientale** Coult. & Rose. WHITE-FLOWERED PARSLEY. Downy, with peduncles 3–8 in. high. Leaves twice pinnate, the segments oblong or ovate, generally cut into rather obtuse linear or nearly linear lobes. Bracts of the involucels lanceolate, with thin membranous margins. Flowers white or pinkish. Fruit oval or round, notched at the base, smooth; oil tubes solitary in the intervals between ribs. Dry soil W.

2. **L. daucifolium** Coult. & Rose. CARROT-LEAVED PARSLEY. Leaves finely dissected into short linear or thread-like segments. Petals yellow. Fruit oval, with prominent dorsal ribs. Prairies W.

IX. PASTINACA L.

A tall, smooth biennial, with a stout, grooved stem. Leaves pinnate. Flowers yellow, in large umbels, with hardly any involucre. Calyx teeth wanting. Fruit oval, very flat, with a thin wing; oil tubes single, running the whole length.

1. **P. sativa** L. Common Parsnip. Cultivated from Europe for its large, conical, sweet and edible roots. Also introduced in waste places.

X. HERACLEUM L.

A stout perennial, with the very large leaves compound in threes. Umbels large, compound, with the involucels many-leaved. Petals white, inversely heart-shaped, the outer ones usually 2-cleft and larger. Calyx with 5 small teeth. Fruit tipped with a thick, conical enlargement of the style, with three blunt ribs on the outer surface of each carpel and a large oil tube in each interval between the ribs. Seeds flat.

1. **H. lanatum** Michx. Cow Parsnip. Stem grooved and woolly, 4–8 ft. high. Leaflets petioled, broad, deeply and irregularly toothed.

XI. DAUCUS L.

Annual or biennial, bristly-hairy herbs. Leaves pinnately twice or more compound, the divisions slender. Umbels compound, many-rayed. Flowers small, white. Calyx teeth slender or wanting. Petals notched, the point bent inward, often unequal. Fruit ovoid or ellipsoid, with rows of spines.

1. **D. Carota** L. Common Carrot. Erect, 1–3 ft. high, with a conical, fleshy, orange-colored root. Lower and basal leaves 2–3-pinnate. Central flower of each umbel and sometimes of each umbellet larger and very dark purple, with the corolla irregular. Cultivated from Europe for the edible roots; also introduced in pastures and meadows and along roadsides E.

74. CORNACEÆ. Dogwood Family

Shrubs or trees, rarely herbs. Leaves opposite or alternate, without stipules. Flowers small, actinomorphic, variously clustered. Limb of the calyx epigynous, very short. Petals 4-5, borne on the margin of a disk on top of the ovary. Stamens 4–5, inserted with the petals. Ovary 1–4-celled, with one ovule in each cell; style 1. Fruit (in our species) a 1-2-celled and 1–2-seeded drupe.

I. CORNUS L.

Trees, shrubs, or herbs. Leaves usually opposite. Flowers in forking cymes, or in umbels or heads, each with an involucre, white or yellow. Calyx teeth 4. Petals 4. Stamens 4. Ovary 2-celled. Drupe ovoidal or ellipsoidal, the stone 2-celled.

1. C. canadensis L. DWARF CORNEL, BUNCHBERRY, PUDDING BERRY. Stem herbaceous, excepting at the base, low (3–9 in.), and unbranched. Rootstock rather woody, slender, and creeping. Leaves in what appears to be a whorl of 4 or 6 at the summit of the stem, sessile, ovate, oval or nearly so, acute at each end, entire, smooth or very slightly downy. Flower stalk slender, $\frac{1}{2}$–$1\frac{1}{2}$ in. long, with a whorl of 4–6 large, white, petal-like bracts, forming an involucre round the small head of greenish flowers; the head with its involucre appearing to others than botanists like a single flower. Fruit nearly spherical, scarlet, about $\frac{1}{4}$ in. in diameter, in a close cluster, sweet and eatable, though rather insipid. Damp woods, especially N.

2. C. florida L. FLOWERING DOGWOOD. Small trees; bark rough, black. Leaves opposite, petioled, ovate to ovate-lanceolate, entire, green and shining above, paler and often downy beneath. Flowers small, greenish, in heads which are subtended by 4 large, white or pink, inversely heart-shaped bracts, thickened and greenish at the notch. Fruit ovoid, bright red. In rich woods S. and E.*

3. C. circinata L'Her. ROUND-LEAVED DOGWOOD. A shrub 3–10 ft. high, with green, warty twigs. Leaves petioled, roundish-oval, contracted to an abrupt point, entire, usually rounded or truncate at the base, pale and soft-downy beneath. Flowers in flat cymes, $1\frac{1}{2}$–$2\frac{1}{2}$ in. in diameter. Fruit globose, light blue, $\frac{1}{4}$ in. or less in diameter. Thickets often in rocky soil N. and along Allegheny Mountains.

4. C. Amomum Mill. KINNIKINNIK. A shrub 6–10 ft. high; twigs purple, downy when young. Leaves opposite, petioled, ovate or oblong, taper-pointed, smooth above, silky-downy below. Flowers white, in rather close cymes. Fruit blue, stone somewhat oblique. In low woods.*

5. C. asperifolia Michx. ROUGH-LEAVED DOGWOOD. A shrub 8–12 ft. high; twigs slender, reddish-brown, often warty, densely downy when young. Leaves opposite, short-petioled, lance-ovate or oblong, acute or taper-pointed, with rough down above, downy-woolly below. Cymes flat, spreading, the peduncle and branches covered with rough down. Flowers white. Fruit white or pale blue, stone depressed-globose. In dry woods.*

6. C. stolonifera Michx. RED OSIER DOGWOOD. A shrub 3–15 ft. high, with smooth, reddish-purple bark on all the younger twigs; spreading by suckers from the base and therefore the stems usually clustered. Leaves on rather slender petioles, acute or taper-pointed, rounded or tapered at the base; covered, at least beneath, by very fine, closely appressed hairs. Fruit white or nearly so, globose, $\frac{1}{4}$ in. or more in diameter. Common in wet ground, especially N.

7. C. alternifolia L. f. ALTERNATE-LEAVED DOGWOOD. A shrub or small tree; twigs greenish, striped. Leaves alternate, often clustered at the ends of the twigs, long-petioled, oval, acute at the apex and often at the base, minutely toothed, pale and covered with fine, appressed hairs beneath. Cymes loose and open; flowers white. Fruit deep blue. Banks of streams.*

II. NYSSA L.

Trees or shrubs. Leaves alternate, petioled, entire or few-toothed. Flowers somewhat monœcious or diœcious, the staminate in many-flowered heads or cymes, the pistillate in small clusters or solitary. Calyx tube 5-toothed or truncate. Petals minute or wanting. Stamens 5–10. Ovary 1-celled, 1-ovuled; style long and recurved. Fruit a 1-seeded drupe.

1. N. sylvatica Marsh. BLACK GUM. A tree with widely spreading branches and dark, rough bark; wood light-colored, very tough; base of trunk often enlarged. Leaves often clustered at the ends of the twigs, oval or obovate, taper-pointed or obtuse at the apex, entire, smooth and shining above, downy beneath, becoming bright red in autumn. Staminate flowers in heads; pistillate flowers 3–10, in a long-peduncled cluster. Fruit ovoid, dark blue or nearly black, $\frac{1}{2}$ in. long; stone slightly ridged. In rich, wet soil S. and E.*

2. N. aquatica L. TUPELO. A large tree, similar to the preceding. Leaves long-petioled, oval or ovate, acute at each end, entire or coarsely toothed, the lower sometimes heart-shaped, smooth above, downy beneath, 4–8 in. long. Staminate flowers in heads; pistillate flowers on long peduncles, solitary. Fruit ovoid, dark blue; stone sharply ridged. In swamps S. and E.*

75. PYROLACEÆ. PYROLA FAMILY

Perennial herbs, evergreen or else pale and without chlorophyll. Petals usually free from each other and falling off separately after flowering. Stamens hypogynous, the anthers without appendages and opening by pores or by a transverse slit. Fruit a capsule containing a great number of very small seeds.

I. CHIMAPHILA Pursh.

Low plants, nearly herbaceous, with reclining stems, from long, horizontal, underground shoots. Leaves opposite or whorled, leathery, shining, evergreen, on short petioles. Flowers fragrant, white or purplish, on a corymb or umbel which terminates the stem. Calyx 5-cleft or 5-parted, persistent. Petals 5, concave, roundish, spreading. Stamens 10, the filaments enlarged and downy in the middle, the anthers somewhat 4-celled, opening when mature by pores at the outer end. Style top-shaped, nearly buried in the top of the globular ovary. Capsule erect, 5-celled.

1. **C. umbellata** Nutt. PRINCE'S PINE, PIPSISSEWA. Branches leafy, 4–12 in. high. Leaves spatulate or wedge-oblanceolate, obtuse or nearly so, sharply serrate, very green and glossy. Flowers several, umbeled or somewhat corymbed, white or pinkish, the anthers violet. Dry woods, especially under pine trees.

2. **C. maculata** Pursh. SPOTTED WINTERGREEN. Much resembles No. 1, but has only scattered teeth on the leaves, which are mottled with white on the upper surface and are often broad or rounded at the base. Dry woods.

II. PYROLA L.

Biennial or perennial, almost woody herbs; rootstocks slender and creeping. Leaves mostly basal, with broad petioles, evergreen. Flowers in racemes, nodding, on a bracted scape. Sepals 5. Corolla usually globose, of 5 free or nearly free, roundish petals. Stamens 10, in pairs opposite the petals, hypogynous; anthers as in *Chimaphila*. Capsule globose, 5-celled, splitting into 5 valves, the latter usually with downy edges.

1. **P. elliptica** Nutt. SHIN LEAF. Scape 5–10 in. high. Leaf blades obovate-oval or elliptical, rather thin, dark green, faintly scalloped, almost always longer than their margined petioles. Flowers greenish-white, very fragrant. Rich, usually dry, woods, especially N.

2. **P. americana** Sweet. ROUND-LEAVED WINTERGREEN. Scape 6–20 in. high. Leaf blades roundish or oval, leathery, shining above,

faintly scalloped, often rounded at the base or almost heart-shaped, usually shorter than the slightly margined petioles. Flowers white, very fragrant. Varies greatly. Usually in dry woods N.

III. MONOTROPA L.

Leafless, simple, erect, white, brown, or red root parasites or saprophytes or fed by slender fungus threads which cluster on the roots. Stem scaly, the upper scales often passing into bracts. Flowers solitary or in spikes or racemes. Sepals or bracts 2–5, erect, deciduous. Petals 4 or 5, erect or spreading. Stamens 8 or 10, hypogynous, the filaments awl-shaped; anthers kidney-shaped. Ovary 4–5-celled; style simple; stigma disk-like, with 4–5 rays.

B.Fl. species 2 (*Hypopitys*).

1. M. uniflora L. Indian Pipe. Stem smooth, fleshy, 4–6 in. high. Bracts ovate or lanceolate. Flower single, tubular, $\frac{3}{4}$–1 in. long, inodorous. Stamens a little shorter than the petals. Capsule angled, $\frac{1}{2}$–$\frac{3}{4}$ in. long. Whole plant waxy-white, turning black in drying. In moist, shady woods N. and E.*

2. M. Hypopitys L. Pinesap. Stems single or clustered, white or reddish, 4–8 in. high. Bracts ovate-lanceolate. Flowers several, in a scaly raceme, fragrant, $\frac{1}{2}$–$\frac{3}{4}$ in. long. Capsule oval, $\frac{1}{4}$ in. long. In dry, shady woods, especially under oaks or pines.*

76. ERICACEÆ. Heath Family

Usually shrubs or slightly shrubby plants. Leaves simple, generally alternate. Corolla commonly actinomorphic, 4–5-cleft, sometimes choripetalous. Stamens hypogynous, distinct, as many or twice as many as the petals; the anthers mostly opening by a hole at the end. Ovary usually with as many cells as there are corolla lobes; style 1. Seeds small, with endosperm.

A

Shrubs or small trees. Calyx free from the ovary. Corolla hypogynous, usually sympetalous.

Shrubs or small trees, with showy flowers. Anthers not held down in pockets in the corolla. Rhododendron, I

Shrubs with showy flowers. Anthers at first held in pocket-like depressions in the corolla. Kalmia, II

Shrubs with small, mostly white, urn-shaped flowers. Lyonia, III

A prostrate plant, hardly at all shrubby. Leaves rather large, often $1\frac{1}{2}$ in. wide, and veiny. Epigæa, IV

A trailing plant with small (about $\frac{1}{4}$ in. wide), thick, evergreen leaves. Arctostaphylos, V

B

Shrubs. Flowers epigynous; corolla sympetalous. Fruit a true berry or resembling one.

Fruit a berry-like drupe, with 10 nutlets which resemble seeds. Gaylussacia, VI

Fruit a berry with many small seeds. Vaccinium, VII

I. RHODODENDRON L.

Shrubs, often much branched. Leaves alternate, thin, deciduous. Flowers very showy, in terminal umbels, from scaly buds which became well developed the previous season. Calyx very small, 5-parted. Corolla bell-shaped, the tube long and slender, the limb spreading and somewhat one-sided. Stamens 5 or 10, declined; anthers awnless. Style long and slender, declined; stigma knobbed. Capsule oblong or linear, 5-celled, many-seeded; seeds very small, scale-like.

1. **R. viscosum** Torr. Swamp Honeysuckle, Swamp Pink. A shrub, 4–6 ft. high; branches hairy. Leaves obovate, leathery, mucronate at the apex, mostly smooth above, downy on the veins beneath; petioles very short. Flowers appearing later than the leaves, white, fragrant, $1\frac{1}{2}$–2 in. long; tube long, glandular-viscid. Capsule erect, $\frac{1}{2}$–$\frac{2}{3}$ in. long, bristly. In swamps.*

2. **R. nudiflorum** Torr. Wild Honeysuckle, Election Pink. A branching shrub, 4–6 ft. high; twigs smooth or with a few coarse hairs. Leaves obovate or oblong, ciliate-serrate, downy, becoming smooth above; petioles short. Flowers appearing with or before the leaves, pink or white, sometimes yellowish, fragrant, 1–2 in. wide, tube downy but not glandular. Capsule erect, linear-oblong, $\frac{2}{3}$–$\frac{3}{4}$ in. long. Swamps and banks of streams; flowers extremely variable in size and color.*

II. KALMIA L.

Erect and branching shrubs. Leaves alternate, opposite or in threes, entire, leathery, evergreen. Flowers showy, in corymbs, or 1–3 in the axils. Calyx 5-parted. Corolla flat-bell-shaped or wheel-shaped, 5-lobed. Stamens 10, the anthers placed in pouches in the corolla, filaments straightening elastically at maturity and so bringing the anthers in contact with any large insect-visitor. Style long and slender. Capsule globose, 5-celled, many-seeded.

1. **K. latifolia** L. CALICO BUSH, MOUNTAIN LAUREL. A shrub, 4–10 ft. high. Branches stout, smooth. Leaves mostly alternate, petioled, elliptical or oval, acute at each end, smooth and green on both sides. Corymbs terminal, compound. Flowers white to rose color, showy, 1 in. broad. Calyx and corolla glandular; pedicels long, slender, sticky-glandular, erect in fruit; calyx and style persistent. Shady banks on rocky or sandy soil.*

2. **K. angustifolia** L. SHEEP LAUREL, LAMBKILL. A shrub, 1–3 ft. high, with smooth, nearly erect branches. Leaves petioled, opposite or in threes, oblong, obtuse at both ends, dark green above, paler beneath. Corymbs lateral, glandular. Flowers purple or crimson, $\frac{1}{2}$–$\frac{1}{3}$ in. broad. Pedicels slender, recurved in fruit. Calyx downy, persistent. Style persistent; capsule depressed-globose. On hillsides; abundant northward.*

III. LYONIA Nutt.

Shrubs or small trees. Leaves alternate, persistent or falling late. Flowers mostly white, in panicles, racemes, or umbels. Calyx 5-parted; corolla urn-shaped. Stamens 10; filaments hairy, often with teeth or appendages; anthers oblong or ovoid. Capsule globose or nearly so, 5-angled. Seeds sawdust-like, with a loose outer coat.

B. Fl. species 1 (*Pieris*); species 2 (*Xolisma*).

1. **L. mariana** D. Don. STAGGERBUSH. A smooth shrub, 20–40 in. high. Leaves oval or oblong, smooth above, slightly downy on the veins beneath. Flowers nodding, on leafless shoots. Filaments with 2 teeth near the apex. Capsule ovoid-pyramidal, truncate at its apex. Low, sandy soil. Foliage said to be poisonous.

2. **L. ligustrina** DC. MALE BERRY. A minutely downy shrub, $1\frac{1}{2}$–10 ft. high. Leaves varying from obovate to ovate, finely serrate or entire. Racemes usually leafless, crowded in terminal panicles. Filaments flat, without appendages. Capsule globose. Moist thickets and swamps.

IV. EPIGÆA L.

Prostrate or trailing shrubs. Stems rusty-downy, 6–12 in. long. Leaves alternate, leathery, evergreen. Flowers in bracted, terminal, close racemes or clusters. Calyx 5-parted, persistent. Corolla salver-shaped, 5-lobed. Stamens 10, about the length of the corolla tube. Ovary 5-lobed; style columnar; stigma 5-lobed. Fruit a globose, hairy, 5-celled, many-seeded capsule.*

1. **E. repens** L. Ground Laurel, Trailing Arbutus, Mayflower. Stems creeping, the young twigs ascending. Leaves oval or somewhat heart-shaped, entire, netted-veined, smooth above, rough-hairy beneath; petioles short, rough-hairy. Racemes shorter than the leaves. Flowers white to bright pink, ½ in. broad, very fragrant. In dry woods, often covering considerable areas.*

V. ARCTOSTAPHYLOS Adans.

Shrubs. Leaves alternate, evergreen. Flowers pinkish or nearly white, in terminal, bracted racemes. Calyx 4–5-parted, persistent. Corolla 4–5-lobed, the lobes recurved. Ovary 5–10-celled, each cell containing 1 ovule. Fruit a berry-like drupe, with 5–10 nutlets.

1. **A. Uva-ursi** Spreng. Bearberry. In trailing clumps, the branches 1–2 ft. high. Leaves evergreen, finely woolly, obovate or spatulate, entire, very leathery. Racemes few-flowered, very short. Corolla urn-shaped, the teeth hairy within. Berry red, ¼ in. in diameter. Rocks and dry hilltops, especially N.

VI. GAYLUSSACIA HBK.

Low, branching shrubs, mostly resinous-dotted. Leaves serrate or entire. Flowers small, white or pink, in lateral, bracted racemes, nodding; pedicels usually 2-bracteolate. Calyx tube short, obconic, the lobes persistent. Corolla ovoid to bell-shaped, 5-lobed, the lobes erect or recurved. Stamens equal, usually included; anthers awnless. Fruit a 10-seeded, berry-like drupe.*

1. **G. frondosa** T. & G. Tangleberry, Dangleberry. An erect shrub, 1–3 ft. high; branches spreading, slender, gray, slightly downy. Leaves entire, oblong or obovate, obtuse, thin, smooth and green above; paler, downy, and with resinous dots, beneath; petioles short.

Racemes few-flowered. Corolla small, greenish-pink, short-bell-shaped; bracts small, oblong, shorter than the pedicels. Berry depressed-globose, dark blue, with bloom, sweet, about ⅓ in. in diameter. On low ground.*

2. G. baccata K. Koch. HUCKLEBERRY. A much-branched, stiff shrub, 1–3 ft. high, slightly downy when young. Leaves oval or oblong, rarely obovate, obtuse or nearly so, entire, covered when young with little resinous particles. Flowers in short, one-sided racemes. Corolla at first conical-ovoid, becoming afterward nearly cylindrical, pink or reddish. Fruit (in the typical form) black, with no bloom, sweet; the seed-like nutlets rather large. Woods and pastures in sandy soil.

VII. VACCINIUM L.

Shrubs or small trees. Leaves entire or serrulate, often leathery and evergreen. Flowers terminal or lateral, clustered or solitary, nodding. Pedicels 2-bracteolate. Calyx tube globose or hemispherical, 4–5-lobed, persistent. Corolla urn-shaped, cylindrical or bell-shaped, 4–5-lobed. Stamens twice as many as the lobes of the corolla; anthers awned or awnless. Ovary 4–5-celled, each cell partially divided by a partition, which makes the ovary appear 8–10-celled; style slender; stigma simple. Fruit a many-seeded berry.*

B. Fl. species 1 (*Batodendron*); species 2 (*Polycodium*); species 6 (*Oxycoccus*).

1. V. arboreum Marsh. FARKLEBERRY. Tree-like, sometimes 30 ft. high; bark gray; twigs slender, smooth or downy. Leaves deciduous, ovate or oval, mucronate, entire or glandular-dentate, leathery, green above, often slightly downy beneath. Racemes with leaf-like bracts; pedicels slender, drooping. Corolla campanulate, white. Anthers included; style projecting. Berry globose, black, mealy, ripening in winter. Common in dry, open woods.*

2. V. stamineum L. DEERBERRY, SQUAW HUCKLEBERRY. An erect shrub, 3–10 ft. high; branches widely spreading, twigs smooth or minutely downy. Leaves deciduous, oval or oblong, acute or taper-pointed at the apex, obtuse or slightly heart-shaped at the base, firm, smooth, and green above, pale and slightly downy beneath, petioled. Racemes with leaf-like bracts. Flowers numerous, drooping, on jointed, slender pedicels. Corolla bell-shaped, purplish-green, 2-awned anthers and style projecting. Berry globose or pear-shaped, inedible. Dry woods.*

3. V. pennsylvanicum Lam. DWARF BLUEBERRY, LOW BLUEBERRY. Low (usually 6–12 in. high, sometimes 2 ft. high) and smooth, with warty green branches. Leaves oblong or oblong-lanceolate, sharply serrate, with little bristle-pointed teeth, both sides smooth and shining except for down occasionally on the midrib and veins below, pointed at both ends. Flowers few in a cluster, longer than their minute pedicels. Corolla oblong, bell-shaped, a little narrowed at the throat, white or pinkish. Berry blue, with much bloom, ripening earlier than the other eatable species, sweeter than No. 5 but not so high-flavored. In dry or sandy soil, especially N.

4. V. vacillans Kalm. LATE LOW BLUEBERRY. A low, stiff, smooth shrub, 1–3 ft. high; branches yellowish-green. Leaves obovate or oval, pale or dull green, smooth beneath, entire or nearly so. Flowers greenish-yellow or somewhat pink. Berries late-ripening, blue, with some bloom, sweet. Dry, especially sandy, soil.

5. V. corymbosum L. HIGH-BUSH BLUEBERRY. An erect shrub, 6–12 ft. high; branches stiff, young twigs minutely warty. Leaves deciduous, oval to ovate-lanceolate, acute, margins bristly, serrulate, smooth or downy, short-petioled. Racemes numerous, appearing with or before the leaves. Bracts oval or oblong, deciduous. Flowers white or pink. Corolla almost as long as the pedicel, cylindrical. Berry globose, blue or black, flavor slightly acid, pleasant. Common in woods and thickets. Whole plant extremely variable.*

6. V. macrocarpon Ait. CRANBERRY. Stems creeping, thread-like, 1–3 ft. or more in length, the branches not quite erect, sometimes 8 in. high. Leaves usually oval or oblong, obtuse, thickish, evergreen, the younger ones with the margins somewhat rolled under. Flowers nodding. Petals strongly reflexed, deep rose-red inside at the base, pale pinkish or almost white at the tips. Stamens with the filaments hardly $\frac{1}{3}$ as long as the anthers. Fruit red or reddish-purple, ellipsoidal or nearly globose, very acid, much valued for sauce, pies, and jellies. Common in peat bogs and wet meadows N.

77. PRIMULACEÆ. PRIMROSE FAMILY

Herbs, with simple leaves, often most or all of them basal. Flowers bisexual and actinomorphic, generally sympetalous. Stamens commonly 5, inserted on the corolla, opposite its lobes. Pistil consisting of a single stigma and style and a (generally free) 1-celled ovary, with a free central placenta.

A

Leaves all basal.

(*a*) Segments of corolla not reflexed, throat open. Stamens included. Primula, I (*b*) As in (*a*), but throat of corolla narrowed. Androsace, II

(*c*) Segments of corolla much reflexed. Stamens protruding. Dodecatheon, VIII

B

Stems leafy, at least near the summit.

(*a*) Corolla yellow. No sterile appendages alternating with the stamens. Lysimachia, III

(*b*) Corolla yellow. Sterile appendages alternating with the stamens. Steironema, IV

(*c*) Corolla white. Stems with leaves mostly whorled near the summit. Trientalis, V

(*d*) Corolla scarlet (sometimes white or blue). Stems low, leafy throughout. Anagallis, VI

(*e*) Corolla inconspicuous, pink. Stems leafy, very short. Centunculus, VII

I. PRIMULA L.

Low, perennial herbs, with much-veined basal leaves ; scapes each bearing an umbel of flowers, which are often showy. Calyx tubular, decidedly angled, 5-cleft. Corolla more or less salver-shaped, with the tube widened above the insertion of the stamens ; the 5 lobes of the limb often notched or cleft. Stamens 5, not protruding outside the corolla tube. Capsule egg-shaped, splitting at the top into 5 valves, each of which may divide in halves.

1. P. grandiflora Lam. TRUE PRIMROSE. Leaves spatulate or obovate-oblong. Flowers rising on separate slender pedicels from the leaf axils. Corolla originally pale yellow, but varying to white, red, and many intermediate shades, with a broad, flat limb. Cultivated from Europe.

2. P. sinensis Sabine. CHINESE PRIMROSE. A rather coarse, downy plant. Leaves round-heart-shaped, more or less lobed and cut, long-petioled. Flowers large, in umbels, usually rose color or white. Calyx large, inflated and conical. Cultivated as a house plant from China.

II. ANDROSACE L.

Small herbs, with clustered basal leaves. Flowers very small, solitary or umbeled. Calyx 5-cleft, with a short tube. Corolla salver- or funnel-shaped, contracted at the throat, its tube shorter than the calyx. Stamens 5, perigynous, not protruding from the tube of the corolla. Capsule 5-valved, few–many-seeded.

1. A. occidentalis Pursh. Annual, smooth or nearly so. Scapes usually clustered, 1–3 in. high, erect or ascending. Lobes of the calyx becoming leafy. Corolla white, shorter than the calyx. In dry soil W.

III. LYSIMACHIA L.

Perennials, with opposite or whorled entire leaves, which are often dotted. Calyx 5–6-parted. Corolla wheel-shaped, with its divisions commonly nearly separate. Stamens generally somewhat monadelphous at the base.

B. Fl. species 4 (*Naumburgia*).

1. L. quadrifolia L. FOUR-LEAVED LOOSESTRIFE. Stem erect and simple, 1–2 ft. high, hairy. Leaves whorled, most frequently in fours, broadly lanceolate. Flowers small, axillary, and solitary, on long and slender peduncles. Damp or sandy soil.

2. L. terrestris BSP. BULB-BEARING LOOSESTRIFE. Stems 1–2 ft. high, finally branching, frequently producing bulblets in the leaf axils after flowering. Leaves abundant, generally opposite, narrowly lanceolate. Flowers small, pediceled, in a long, terminal raceme. Low or swampy ground.

3. L. Nummularia L. MONEYWORT. Stems creeping, smooth. Leaves small, round or nearly so. Flowers solitary in the leaf axils, yellow, $\frac{1}{2}$–1 in. in diameter. Cultivated and escaping into moist ground. Introduced from Europe.

4. L. thyrsiflora L. TUFTED LOOSESTRIFE. Stem simple, erect, 1–2 ft. high. Leaves all opposite and lanceolate except the lower ones. Racemes spike-like, 1 in. or less long, borne in the leaf axils near the middle of the stem. Flowers small, light yellow with black spots. In swamps.

IV. STEIRONEMA Raf.

Perennial herbs. Leaves opposite or whorled, simple, entire. Flowers yellow, axillary or racemose, on slender peduncles. Calyx tube 5-parted, persistent. Corolla 5-parted, wheel-shaped, tube very short or none, the lobes denticulate at the apex, and in the bud each one inclosing a stamen. Stamens 5, distinct or slightly united at the base; sterile rudiments often alternating with them. Ovary globose; style slender. Fruit a globose, 5-valved, few- or many-seeded capsule.*

1. S. ciliatum Raf. FRINGED LOOSESTRIFE. Stems erect, slender, simple or branched, 1–3 ft. high. Leaves opposite, ovate to ovate-lanceolate, acute at the apex, rounded at the base; margins and petioles hairy-fringed. Flowers solitary on axillary peduncles, $\frac{3}{4}$–1 in. broad; petals broadly ovate or roundish, denticulate; calyx shorter than the capsule. Woods and thickets.*

2. S. lanceolatum Gray. LANCE-LEAVED LOOSESTRIFE. Stem erect, 6–24 in. high. Leaves varying from lanceolate to oblong and linear, petioled or almost sessile, acute or taper-pointed. Flowers $\frac{3}{8}$–$\frac{3}{4}$ in. in diameter. Capsule nearly as long as the segments of the calyx. In moist ground and thickets.

3. S. quadriflorum Hitchc. LINEAR-LEAVED LOOSESTRIFE. Stem erect, 4-sided, slender, 1–3 ft. high. Basal leaves oblong or linear-oblong, on slender petioles; stem leaves, all but the lowest, nearly or quite sessile, narrowly linear, 2–4 in. long, smooth and shining. Flowers about $\frac{3}{4}$ in. in diameter, often clustered in fours at the ends of the branches. Corolla lobes pointed. Along streams, especially N.W.

V. TRIENTALIS L.

Low, smooth, perennial herbs, with slender, erect, unbranched stems. Leaves lanceolate, ovate, or oblong, mostly in a whorl at the summit of the stem. Flowers one or few, terminal, on slender peduncles, small, white or pink. Sepals narrow and spreading. Corolla wheel-shaped, with usually 7 taper-pointed segments. Ovary globose; style thread-like. Capsule globose, many-seeded.

1. T. americana Pursh. STAR FLOWER, CHICKWEED WINTERGREEN. Spreading by long and slender rootstocks; branches erect, stem-like, 3–9 in. high. Leaves very thin, pale green, pointed at both ends. Flowers white. Capsules white, marked off into polygonal sections, each corresponding to 1 seed. Cold woods; common N.

VI. ANAGALLIS L.

Annual or perennial herbs. Stems erect or diffuse. Leaves opposite or whorled. Flowers axillary, peduncled. Calyx tube 5-parted, persistent. Corolla wheel-shaped, 5-parted, longer than the calyx. Stamens 5, inserted on the base of the corolla; filaments bearded. Ovary globose; style slender; stigma knobbed. Fruit a many-seeded capsule, the top coming off like a lid.*

1. A. arvensis L. Poor Man's Weatherglass, Pimpernel. Annual; stem spreading, widely branched, 4-angled, smooth, 4–12 in. long. Leaves opposite, sessile, ovate, black-dotted beneath. Flowers on peduncles longer than the leaves, nodding in fruit. Corolla fringed with glandular hairs, longer than the acute calyx lobes, bright red (sometimes white or blue), opening in sunshine. Capsule globose, tipped by the persistent style. Introduced, and common in fields and gardens.*

VII. CENTUNCULUS L.

Small annuals, with alternate entire leaves. Flowers axillary and solitary, inconspicuous. Calyx 4–5-parted. Corolla 4–5-cleft, shorter than the calyx, the tube urn-shaped. Stamens 4–5, perigynous, with short filaments. Capsule globose, many-seeded, the top falling off as a lid.

1. C. minimus L. Chaffweed, False Pimpernel. Stems 1–6 in. high. Leaves spatulate or obovate, with short petioles. Flowers small, pink, nearly sessile, parts of the perianth usually in fours. Moist soil W.

VIII. DODECATHEON L.

A smooth, perennial herb, with a cluster of oblong or spatulate basal leaves, fibrous roots, and an unbranched scape, leafless except for an involucre of small bracts at the summit, with a large umbel of showy, nodding flowers. Calyx deeply 5-cleft, with reflexed, lanceolate divisions. Tube of the corolla very short, the divisions of the 5-parted limb strongly reflexed. Filaments short, somewhat united at the base; anthers long, acute, and combining to form a conspicuous cone.

1. D. Meadia L. Shooting Star, Indian Chief. Corolla varying from rose color to white. In rich woods in most of the Middle and Southern states. Often cultivated.

78. EBENACEÆ. Ebony Family

Trees or shrubs. Leaves alternate, entire, pinnately veined, without stipules. Flowers often diœcious. Calyx free from the ovary, persistent. Stamens 2–4 times as many as the divisions of the corolla. Ovary 3–12-celled; ovules 1 or 2 in each cell. Fruit a berry. Mostly tropical plants.

DIOSPYROS L.

Flowers diœcious or somewhat monœcious, the staminate ones in cymes, the pistillate ones axillary and solitary. Calyx 4–6-lobed. Corolla 4–6-lobed. Stamens in the staminate flowers usually 16, in the pistillate ones 8, imperfect. Fruit large, with the persistent calyx attached to its base, 4–8-seeded.

1. D. virginiana L. PERSIMMON. Trees, with rough, black bark, and very hard wood. Leaves oval or ovate-oblong, acute or acuminate at the apex, rounded or slightly cordate at the base, entire and dark green, smooth above, pale and often downy beneath, short-petioled, deciduous. Flowers yellowish-white, the parts mostly in fours. Fruit globose, edible when ripe, very astringent when green; seeds large, compressed, often wanting. Fruit ripening late in the fall. Common in old fields and along roadsides S. and S.W.*

79. OLEACEÆ. OLIVE FAMILY

Shrubs or trees. Leaves opposite, simple or odd-pinnate, without stipules. Flowers usually in forking cymes, small, white, greenish or yellow, bisexual or unisexual. Calyx free from the ovary, 4-lobed or wanting. Corolla hypogynous, regular, 4-parted or of 4 separate petals, sometimes wanting. Stamens 2, borne on the petals or hypogynous. Ovary 2-celled. Fruit 1–2-celled, each cell 1-seeded, rarely 2-seeded (in *Forsythia* many-seeded).

I. FRAXINUS Tourn.

Deciduous trees. Flowers diœcious. Petals wanting (in our species). Stamens 2, hypogynous. Fruit a 1–2-celled key, each cell 1-seeded.

1. F. americana L. WHITE ASH. A large tree; bark rough, gray; wood hard, strong, elastic; twigs and petioles smooth. Leaflets usually 7, ovate to ovate-lanceolate, taper-pointed at the apex, rounded or obtuse at the base, entire or slightly serrate, smooth above, often downy beneath, short-stalked. Flowers mostly diœcious. Calyx of the pistillate flowers persistent. Key $1\frac{1}{2}$–2 in. long, winged only at the apex; wing spatulate or oblanceolate. In rich woods and swamps.*

2. F. pennsylvanica Marsh. RED ASH. A small tree; bark rough, dark gray; twigs and petioles densely velvety-downy. Leaflets 5–9, oblong-ovate to ovate-lanceolate, taper-pointed at the apex, narrowed into a short stalk at the base, finely serrate, smooth above, velvety-downy beneath. Calyx of the pistillate flowers persistent. Key 1½–2 in. long, the wing somewhat extended along the sides, oblanceolate or spatulate, often notched. Swamps and moist soil.*

3. **F. caroliniana** Mill. WATER ASH. A small tree; wood soft, light, and weak; twigs smooth or downy. Leaflets 5–7, ovate or elliptical, acute at the apex, acute or obtuse at the base, entire or slightly serrate, smooth or slightly downy, stalked. Flowers diœcious. Calyx persistent. Key often 3-angled or 3-winged, wings running nearly to the base, oblong or oval, pinnately veined. In swamps and wet soil.*

4. **F. quadrangulata** Michx. BLUE ASH. A large tree, with wood heavy, but not as tough as No. 1; the most vigorous twigs usually square. Leaflets 7–9, with short stalks, somewhat ovate or lanceolate, acute, sharply serrate. Fruit winged to the base, of nearly the same width throughout, narrowly oblong. Rich woods, especially W.

II. FORSYTHIA Vahl.

Shrubs. Leaves opposite or in threes, appearing later than the flowers, serrate. Calyx very short, deciduous. Corolla yellow, bell-shaped, its lobes long and slender. Stamens inserted on the base of the corolla tube. Pod 2-celled, many-seeded.

1. **F. viridissima** Lindl. A hardy shrub, with branches erect or nearly so. Leaves all simple, lance-oblong. Calyx lobes half as long as the tube of the corolla. Lobes of the corolla spreading, narrow-oblong. Style equal in length to the tube of the corolla. Cultivated from Asia.

2. **F. suspensa** Vahl. A hardy shrub, with drooping branches. Leaves broadly ovate, often some of them with 3 leaflets, the lateral leaflets small. Lobes of the corolla longer, broader, and more spreading than in No. 1. Style shorter than the tube of the corolla. Cultivated from Asia. Less common than No. 1; often trained over porches and arbors.

III. SYRINGA L.

Tall shrubs, forking frequently, from the failure of the terminal buds on most branches. Leaves simple, entire. Flowers in close, compound panicles. Calyx 4-toothed. Corolla salver-shaped, the tube long, the limb 4-lobed. Pod dry, flattened at right angles to the partition, 4-seeded.

1. **S. vulgaris** L. COMMON LILAC. A strong-growing, hardy bush. Leaves ovate, somewhat heart-shaped. Flowers sweet-scented, in very close, large clusters, lilac or white. Corolla lobes concave. Very commonly cultivated from eastern Europe.

2. S. persica L. Persian Lilac. A more slender and less branched shrub than No. 1. Leaves lance-ovate, somewhat narrowed or tapering at the base. Flowers in rather loose clusters, not very sweet-scented, pale lilac or white. Corolla lobes ovate, somewhat bent inward. Pods linear. Cultivated from western Asia, less common than No. 1.

IV. CHIONANTHUS L.

Shrubs or small trees. Leaves simple, opposite, entire, petioled, deciduous. Flowers in panicles borne on wood of the previous season. Calyx small, 4-cleft, persistent. Corolla wheel-shaped, 4-parted, the lobes long and linear. Stamens 2–4, included, inserted on the base of the corolla. Style short; stigma 2-lobed. Fruit a 1-seeded drupe.*

1. C. virginica L. Fringe Tree, Old Man's Beard. A small tree, with smooth, light gray bark and spreading branches. Leaves oval to oblong, acute or obtuse at each end, smooth or slightly downy. Panicles large and loose, leafy-bracted, appearing with the leaves. Flowers on slender, drooping pedicels. Petals 1 in. or more in length. Fruit ovoid, purple, $\frac{1}{2}$–$\frac{2}{3}$ in. long. Along streams, usually on light soil.*

V. LIGUSTRUM L.

Shrubs. Leaves simple, opposite, entire, deciduous or sometimes persistent. Flowers in terminal panicles or similar clusters, white, small. Calyx minutely 4-toothed or truncate. Corolla funnel form, 4-lobed. Stamens 2, short, inserted in the tube of the corolla. Ovary free, 2-celled, 2 ovules in each cell; style short. Fruit a 1–4-seeded, globose berry.*

1. L. vulgare L. Privet. A branching shrub, 4–10 ft. high; branches long and slender. Leaves somewhat leathery, lanceolate to obovate, short-petioled, tardily deciduous. Panicles dense, minutely downy. Flowers $\frac{1}{4}$ in. wide, fragrant. Stamens included. Berries black. Introduced from Europe and used largely for hedges.*

80. GENTIANACEÆ. Gentian Family

Annual or perennial herbs. Leaves entire, usually opposite, sometimes alternate, without stipules. Flowers actinomorphic, solitary or in cymes. Calyx hypogynous, 4–8-toothed or lobed. Corolla hypogynous, wheel-, bell-, or funnel-shaped, 4–8-lobed. Stamens 4–8, inserted on the corolla tube; filaments thread-shaped; anthers facing inwards. Ovary 1–2-celled; ovules many, on 2 opposite placentas. Capsule 1-celled or partially 2-celled, 2-valved, many-seeded. [The best known genus, *Gentiana*, consists mainly of autumn-flowering species.]

I. OBOLARIA L.

A low, smooth, purplish-green perennial. Flowers axillary and terminal. Calyx of 2 distinct, spatulate, bract-like sepals. Corolla tubular-bell-shaped, 4-lobed. Stamens short, inserted at the notches of the corolla. Style short; stigma 2-lipped. Capsule ovoid, more or less 2–4-celled; seeds very minute and numerous.

1. O. virginica L. PENNYWORT. Stem 3–8 in. high, often several from the same root. Leaves somewhat fleshy, wedge-obovate or somewhat diamond-shaped, often truncate, sessile. Flowers opposite or terminal in threes, nearly sessile. Corolla pale purple or nearly white. Rich woodlands, among dead leaves.

II. MENYANTHES L.

Perennial, scape-bearing marsh herbs. Rootstock creeping. Leaves of 3 leaflets. Flowers racemed. Calyx 5-parted. Corolla fleshy, funnel-shaped, the limb 5-parted. Stamens 5, inserted on the corolla tube. Disk of 5 hypogynous glands. Ovary 1-celled; style thread-shaped; stigma 2-lobed. Capsule globose, many-seeded.

1. M. trifoliata L. BUCK BEAN, MARSH TREFOIL. Rootstocks stout and matted. Leaflets obtuse, entire. Flowers $\frac{2}{3}$ in. in diameter, white or pinkish. Bogs, especially N.

81. APOCYNACEÆ. DOGBANE FAMILY

Trees, shrubs, or herbs, with milky juice, often climbing. Leaves usually opposite, rarely whorled, entire, nearly or quite without stipules. Flowers actinomorphic, solitary or in cymes. Calyx 4–5-cleft. Corolla hypogynous, funnel-, salver-, or bell-shaped, sometimes with scales in the throat. Stamens 4–5, borne on the corolla tube or throat; filaments very short;

anthers somewhat attached to the stigma. Ovary of 2 carpels, free or somewhat united; style short; stigma entire or 2-cleft. Fruit of 2 many-seeded pods (in the genera here described).

I. AMSONIA Walt.

Perennial herbs. Stems erect, branched. Leaves alternate. Flowers in terminal panicles. Calyx small, 5-parted. Corolla small, pale blue, funnel- or salver-form, downy within. Stamens inserted above the middle of the tube, included. Ovary of 2 carpels, united at the top by the slender style; stigma globose, surrounded by a cup-shaped appendage. Fruit 2 slender, erect, many-seeded follicles; seeds without tufts of hairs.*

1. A. Tabernæmontana Walt. Amsonia. Stem smooth and glabrous, branched above, 2–3 ft. high. Leaves lanceolate, entire, acuminate at the apex, acute at the base, smooth above, with a bloom or slightly downy beneath, short-petioled. Flowers numerous, on bracted pedicels. Corolla tube slender, smooth or sometimes downy above; the lobes narrow, as long as the tube. Follicles slender, spreading, 4–6 in. long; seeds downy. Swamps and wet ground S.*

II. VINCA L.

Perennial herbs or small, slender shrubs; juice not perceptibly milky. Leaves evergreen. Flowers solitary, white, blue, or purple. Calyx 5-parted; lobes taper-pointed, glandular inside at the base. Corolla salver-shaped, thickened at the throat, 5-lobed. Stamens 5, inserted on the upper or middle part of the corolla tube. Ovary of 2 carpels. Pods 2, slender, cylindrical, many-seeded.

1. V. minor L. Periwinkle. Stem slender, trailing, often rooting at the nodes, 1–3 ft. long. Leaves ovate, acute at the apex, short-petioled, bright green.* Flowers axillary, solitary, 1 in. wide. Calyx with linear lobes nearly as long as the inflated tube of the blue corolla. Matured pods slender, slightly divergent. Introduced from Europe and common in gardens.*

III. APOCYNUM L.

Perennial herbs. Stems with very tough bark, branched above. Leaves opposite, entire. Flowers in terminal and axillary bracted cymes. Calyx small, 5-parted, lobes acute.

Corolla bell-shaped, 5-lobed, with a small, scale-like appendage at the base of each lobe. Stamens 5, distinct, inserted on the base of the corolla tube. Ovaries 2, distinct, united by the styles; stigma obtuse, 2-lobed. Pods long, slender, many-seeded; seeds with a tuft of hairs.*

1. **A. androsæmifolium** L. DOGBANE. Plant 2–3 ft. high, usually smooth, purplish, the branches spreading and forking. Leaves 2–3 in. long, acute, mucronate; petioles about ¼ in. long. Cymes mostly terminal, few-flowered. Calyx teeth lance-ovate, about half as long as the corolla tube. Corolla pale red or whitish, its lobes recurved. Pods stouter than in No. 2. Roadsides and clearings; common.

2. **A. cannabinum** L. INDIAN HEMP. Stem erect, smooth, with numerous erect or ascending branches. Leaves oval to oblong, mucronate at the apex, rounded at the base, downy beneath, short-petioled. Cymes terminal, compact, shorter than the leaves. Flowers are on short, bracted pedicels, greenish-white, about ¼ in. broad. Calyx lobes lanceolate, nearly as long as the tube of the corolla. Corolla lobes erect. Pods very slender, tapering, 3–4 in. long. Along fences and in thickets.*

IV. NERIUM L.

Shrubs. Leaves mostly whorled in threes. Flowers in terminal cymes. Calyx small, lobes acute. Corolla salverform, the throat of the tube crowned with cleft or cut-fringed scales. Stamens 5, short, included; anthers tipped with a hairy bristle. Ovary of 2 carpels; style short. Pods erect; seeds with a tuft of hairs.*

1. **N. Oleander** L. OLEANDER. Stem erect, diffusely branched from below, 4–10 ft. high. Leaves narrowly elliptical, acute at each end, thick and leathery, short-petioled. Flowers showy, in large clusters, red or white, often double; scales of the crown 3–4-pointed unequal teeth. Pods spindle-shaped, 3–4 in. long. Introduced from Palestine. Common in cultivation.*

82. ASCLEPIADACEÆ. MILKWEED FAMILY

Shrubs or herbs, often twining; juice usually milky. Leaves generally opposite or whorled, entire, without stipules. Flowers regular. Calyx 5-parted. Corolla 5-parted. Stamens 5: the filaments usually united around the styles, often with hood-like appendages, each with an incurved horn borne on the stamen tube and forming a crown around the stigma (Fig. 27, *A*); anthers pressing against the lobes of the stigma; the pollen clinging together in tough, waxy or fine-grained

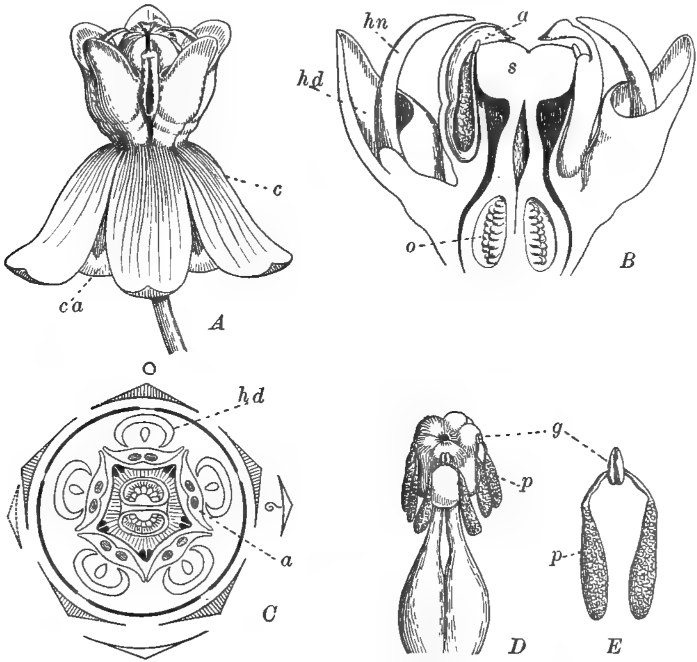


FIG. 27. Flower of *Asclepias syriaca*

A, entire flower; *B*, vertical section; *C*, diagram; *D*, details of pollen-masses and glands. *ca*, calyx; *c*, corolla; *hd*, hood; *hn*, horn; *a*, anther; *s*, stigma; *o*, ovary; *g*, gland; *p*, pollen-mass. (All considerably enlarged.)

masses. Ovary free from the calyx tube, of 2 carpels, more or less united below but unconnected above; styles 2; stigmas 5-angled; ovules several–many. Fruit consisting of 1 or 2 pods. The flowers are very highly specialized for pollination by insects (see below, under *Asclepias*).

I. ASCLEPIODORA Gray.

Plants much like *Asclepias,* but the hoods without horns. Lobes of the corolla ascending or spreading.

1. A. viridis Gray. GREEN MILKWEED. Stems about 1 ft. high, nearly smooth. Leaves alternate, short-petioled, oblong to ovate-lanceolate. Umbels clustered. Flowers about 1 in. in diameter, green with a purplish crown. In dry soil W. and S.

II. ASCLEPIAS L.

Perennial herbs. Flowers in simple (usually many-flowered) umbels. Calyx small, 5-parted, its lobes reflexed. Corolla deeply 5-parted, with reflexed lobes; crown of hoods and horns conspicuous (Fig. 27, *A*, *B*). Stamens with their filaments united into a tube around the pistil and anthers attached to the stigma (Fig. 27, *D*, *E*); anther cells 2, each cell containing an elongated, pear-shaped, tough mass of pollen, a mass from one anther always paired with one from the adjoining anther and each two together suspended from one of the 5 split glands on the angles of the stigma (Fig. 27, *D*, *E*). Ovaries 2; styles very short. Pods 2 or sometimes 1 and the other undeveloped. Seeds flat, each with a tuft of long, silky hairs. The flowers are pollinated by insects, which get their feet entangled in the clefts of the glands (Fig. 27, *g*) and then carry off the pollen masses.

1. A. tuberosa L. BUTTERFLY WEED, PLEURISY ROOT. Stems roughish-hairy, 1–2 ft. high. Juice not milky. Leaves abundant, linear to lanceolate-oblong. Flowers showy, usually bright orange, in terminal cymose umbels. Horns nearly erect and slender. Pods nearly erect, covered with fine down. In dry fields.

2. A. decumbens L. RECLINING BUTTERFLY WEED. Much resembling *A. tuberosa*, but the stems reclining with the ends erect. Leaves elliptic or oblong. Umbels racemed along the branches. In dry soil.

3. A. purpurascens L. PURPLE MILKWEED. Stem 1–3 ft. high, somewhat branched above. Leaves 4–6 in. long, elliptical or nearly so, the upper ones taper-pointed, slightly velvety beneath, short-petioled. Umbels terminal. Flowers $\frac{1}{2}$ in. long, dark purple; pedicels shorter than the peduncle; horn broadly scythe-shaped, with the point bent sharply inward. Dry soil.

4. **A. syriaca** L. COMMON MILKWEED. Stem stout, 3–4 ft. high, finely downy. Leaves 4–8 in. long, oblong or nearly so, downy beneath. Umbels terminal or nearly so. Flowers varying from purple or greenish-purple to whitish, numerous, with a strong, sweet but sickening odor; hoods with a tooth on each side of the stout horn. Common in rich soil.

5. **A. phytolaccoides** Pursh. POKE-LEAVED MILKWEED. Stem rather slender, 3–5 ft. high. Leaves 6–9 in. long, ovate or oval-lanceolate, taper-pointed, short-petioled. Umbels several, mostly lateral; pedicels slender and drooping. Lobes of the corolla greenish; hoods white, with 2 teeth; horns with an awl-shaped point extending far out of the hoods. Damp thickets N. and E.

6. **A. variegata** L. WHITE MILKWEED. Stem stout, leafless and smooth below, leafy and downy in lines above. Leaves opposite, the middle ones sometimes in fours, petioled, ovate to obovate, cuspidate, smooth on both sides, pale beneath, edges slightly crenate. Umbels 1–5, compact, downy, 1–2 in. long; pedicels erect, as long as the peduncles. Corolla white, often purple at the base; hoods roundish, spreading, a little longer than the thick, awl-pointed, incurved horn. Dry, open woods E. and S.*

7. **A. quadrifolia** L. FOUR-LEAVED MILKWEED. Stem slender, 1½–2 ft. or more high, usually leafless below. Leaves in 1 or 2 whorls of 4 each, near the middle of the stem, and a pair or two opposite, thin, slender-petioled, 2–4 in. long, ovate-lanceolate, taper-pointed. Umbels usually 2, sometimes 1, with slender pedicels. Corolla lobes very pale pink or whitish; hoods white; horn short, stout, and bent inward. Dry woods and fence rows.

III. HOYA R. Br.

Shrubby, more or less climbing, smooth, tropical plants. Leaves fleshy. Calyx 5-cleft; corolla 5-lobed, wheel-shaped, its divisions thick and with a waxy look; crown of 5 spreading segments; pollen masses fastened by the bases.

1. **H. carnosa** R. Br. WAX PLANT. Stems long and slender, rooting and trailing. Leaves oval or nearly so, thick, dark green. Flowers in close umbels, pink or whitish, the corolla lobes covered on the upper surface with minute projections. Cultivated from India as a house plant and in conservatories.

83. CONVOLVULACEÆ. MORNING-GLORY FAMILY

Usually twining herbs or shrubs, often with milky juice. Leaves alternate (wanting in *Cuscuta*), without stipules.

Flowers variously clustered, rarely solitary, often large and showy. Sepals 5. Corolla hypogynous, regular, tubular, bell-shaped or funnel-shaped; its limb more or less 5-lobed or angled. Stamens 5, inserted on the corolla tube. Ovary usually 2–4-celled; style slender, 2–4-cleft; ovules 1 or 2 in each cell. Capsule 1–4-celled, 2–4-valved, or bursting open across the base.

I. IMPOMŒA L.

Annuals or perennials; stems often twining. Flowers showy. Calyx not bracted at the base, of 5 sepals. Corolla bell-shaped or funnel-shaped, twisted in the bud. Stamens not projecting from the corolla. Style slender; stigma knobbed, 2-lobed. Fruit a 2–3-celled capsule. [*I. purpurea*, the common morning-glory, blossoms too late for school study. *I. Batatas*, the sweet potato, seldom flowers.]

B. Fl. species 1 (*Quamlocit*).

1. **I. Quamlocit** L. Cypress Vine. Stem slender, smooth, twining high. Leaves dark green, pinnately cut, the divisions linear, smooth. Peduncles slender, as long as the leaves, 1–5-flowered; pedicels thickened upward. Sepals ovate or oblong, mucronate. Corolla bright scarlet, or sometimes yellowish-white, salverform; the tube 1–1½ in. long; the limb flat and spreading, ½–¾ in. wide. Capsule ovoid, twice the length of the sepals. Common in gardens.*

2. **I. hederacea** Jacq. Wild Morning-Glory. Stems hairy, twining. Leaves heart-shaped, 3-lobed. Peduncles 1–3-flowered. Calyx very hairy below. Corolla showy, bluish-purple or white. Pod usually 3-celled, with 2 seeds in each cell. A weed in fields and about dwellings. Introduced from tropical America.

3. **I. pandurata** G. F. W. Mey. Wild Potato Vine. Perennial, from a very large, tuberous root; stem trailing or twining, smooth or slightly downy, 5–10 ft. long. Leaves broadly heart-shaped, with the apex slender and obtuse, sometimes fiddle-shaped or 3-lobed; petioles slender. Peduncles longer than the petioles, 1–5-flowered. Sepals oblong, obtuse, smooth, mucronate, the 2 outer ones shorter. Corolla white with a purple throat, 2–3 in. wide, lobes pointed. Capsule globose, 2–3-seeded, the seeds woolly on the angles. On dry or damp sandy soil, along fences, railroad embankments, etc.; common S. and W.*

4. **I. leptophylla** Torrey. Bush Morning-Glory. Perennial. Stems smooth, much branched, erect, ascending or reclining, 2–4 ft.

long, from a huge root. Leaves 2–5 in. long, short-petioled, linear, acute. Peduncles short, 1–4-flowered. Sepals broadly ovate, obtuse. Corolla pink or purple, funnel-shaped, about 3 in. long. Pod ovoid, 2-celled. Plains W. and S.W.

II. CONVOLVULUS L.

Herbs or shrubs, with stems twining or nearly erect. Calyx not bracted, or inclosed in 2 large, leaf-like bracts. Corolla broadly funnelform or bell-shaped. Stamens not projecting from the corolla. Style 1; stigmas 2; ovary and pod 1–2-celled, 4-seeded.

1. **C. spithamæus** L. Downy, stem 6–12 in. high, erect or reclining. Leaves oblong, sometimes heart-shaped or eared at the base. Flowers white. Calyx inclosed by 2 large, oval, acutish bracts. Stigmas stout. In sandy soil.

2. **C. repens** L. Trailing Bindweed. Stems downy, 1–3 ft. long, trailing or twining. Leaves sometimes heart-shaped, often narrowly arrow-shaped, with the lobes at the base obtuse or rounded. Peduncles 1-flowered. Corolla white, or sometimes pink. Stigma ellipsoidal. Bracts beneath the calyx 2, ovate. In fields.

3. **C. sepium** L. Creepers, Rutland Beauty. Stem twining or sometimes extensively trailing. Leaves heart-arrow-shaped or somewhat halberd-shaped, the lobes at the base truncate. Flowers numerous and showy, white or tinged with rose color. Bracts at the base of the flower large, ovate, heart-shaped. Thickets and banks of streams, often cultivated.

4. **C. arvensis** L. Bindweed. A perennial, prostrate or climbing herb, with many stems, from a long, slender rootstock. Leaves very variable, more or less arrow-shaped, 1–3 in. long. Peduncles mostly 1-flowered; flowers white or pinkish, about $\frac{3}{4}$ in. long. Calyx not bracted. Stigmas linear. A weed in fields E.; adventive from Europe.

84. POLEMONIACEÆ. Phlox Family

Annual or perennial herbs, rarely shrubs. Leaves alternate or the lower opposite, without stipules. Flowers in terminal, forking cymes. Calyx hypogynous, 5-lobed. Corolla regular or nearly so, 5-parted. Stamens 5, inserted on the corolla tube, usually unequal. Ovary 3-celled; style simple; stigmas 3, linear; capsule 3-celled, the cells 1–many-seeded.

I. PHLOX L.

Perennial or rarely annual herbs; stems erect or diffuse. Leaves opposite, or the upper alternate, entire, without stipules. Flowers showy, white or purple, in terminal cymes or panicles. Calyx cylindrical or funnelform, 5-cleft, the lobes acute. Corolla salver-form, the tube long and slender, the limb 5-parted, the lobes spreading, entire or obcordate. Stamens included, unequal. Ovary 3-celled, style slender. Capsule ovoid, 3-celled, 1–few-seeded; seeds wingless or narrow-winged.*

1. P. paniculata L. GARDEN PHLOX. Perennial; stems in clumps, stout, erect, simple or branched above, 2–4 ft. high. Leaves ovate-lanceolate to oblong, taper-pointed at the apex, rounded or cordate at the base, thin, smooth; veins prominent beneath. Cymes numerous and compact, forming a pyramidal panicle; pedicels short. Calyx teeth long, bristle-pointed. Corolla purple to white; lobes round-obovate, shorter than the tube. Capsule longer than the calyx tube. In rich woods; often cultivated.*

2. P. maculata L. WILD SWEET WILLIAM. Stem erect, smooth or nearly so, rather slender, purple-spotted, 1–2 ft. high. Lower leaves lanceolate, the upper ones broader, taper-pointed, roundish or heart-shaped at the base. Panicle many-flowered, narrow, ellipsoidal. Calyx teeth lanceolate, hardly acute. Flowers purple, occasionally white. Damp woods and fields.

3. P. glaberrima L. SMOOTH PHLOX. Stems smooth, slender, erect, 1–3 ft. high. Leaves narrowly lanceolate or linear, 1½–4 in. long, smooth except the rough and sometimes recurved margins. Cymes few-flowered, grouped in loose corymbs. Calyx teeth very narrow and sharp-pointed. Corolla pink or whitish, lobes longer than the tube. Prairies and open woods.

4. P. pilosa L. DOWNY PHLOX. Perennial; stem erect, slender, simple or branched, 1–2 ft. high. Leaves linear-lanceolate to linear, distant, spreading, long, taper-pointed, sessile; stem and leaves downy. Cymes corymbose, loose. Flowers short-pediceled. Calyx glandular-viscid, the teeth shorter than the tube of the purple corolla, bristle-pointed. Corolla tube downy, lobes obovate. Capsule twice the length of the calyx tube. In dry, open woods.*

5. P. divaricata L. WILD BLUE PHLOX. Perennial; stems erect or ascending from a decumbent base, sticky-downy, 1 ft. high. Leaves distant, lanceolate to oblong, acute at the apex, rounded at the base, sessile, downy. Cymes corymbed, loosely flowered. Calyx teeth awl-shaped, longer than the tube. Corolla bluish-purple, ½–¾ in. long; lobes notched at the apex, as long as the tube. Capsule oval, shorter than the calyx teeth. In moist, open woods.*

6. P. Drummondii Hook. DRUMMOND'S PHLOX. Annual; stem erect or ascending, slender, weak, branching, glandular-downy, 6–12 in. high. Leaves mostly alternate, lanceolate to oblong, downy, the upper clasping by a heart-shaped base. Corymbs loose. Flowers rather long-pediceled. Calyx tube short, the teeth lanceolate, bristle-pointed, soon recurved. Corolla purple to crimson or white; orifice of the tube usually with a white or yellowish star-like ring; lobes rounded at the apex. Ovary 3-seeded; angles of the seeds winged. Introduced from Texas and common everywhere in gardens.*

7. P. subulata L. GROUND PINK, MOSS PINK, FLOWERING MOSS. Stems perennial, prostrate, 8–18 in. long, with many short, somewhat upright branches, 2–4 in. high. Leaves linear-awl-shaped, stiff, about ½ in. long, crowded, with clusters of smaller ones in their axils. Flower clusters 3–6-flowered. Corolla pink-purple, with a darker center, or sometimes white. Forms dense mats on rocky or sandy hillsides. S. and W. and often cultivated.

II. POLEMONIUM L.

Perennial herbs. Leaves alternate, pinnate. Flowers in corymbs. Calyx bell-shaped, 5-lobed. Corolla wheel-shaped, the limb with 5 obovate lobes. Stamens borne on the throat of the corolla, the filaments enlarged and hairy below. Capsule ovoid, 3-celled, many-seeded.

1. P. reptans L. JACOB'S LADDER, BLUE VALERIAN, BLUEBELL. Stems smooth, branched, and leaning over, 6–12 in. high. Leaflets usually 7 or 9, about an inch long. Corolla blue, about 3 times as long as the calyx. Capsule 3-seeded, borne on a short stalk in the persistent calyx. Damp, open woods, sometimes cultivated.

85. HYDROPHYLLACEÆ. WATERLEAF FAMILY

Herbs, usually hairy. Leaves commonly alternate and alternate-lobed. Flowers with their parts in fives, in appearance not unlike those of the following family, in one-sided cymes, which are coiled up at first. Calyx free from the ovary, usually with appendages at the notches. Corolla often with scales or nectar-bearing folds inside. Stamens borne by the corolla tube. Style 2-cleft, or styles 2. Ovary entire and usually 1-celled. Fruit a capsule, 2-valved, 4–many-seeded.

I. HYDROPHYLLUM L.

Coarse perennials. Leaves large, petioled. Flowers white or pale blue, inconspicuous. Calyx 5-parted, sometimes appendaged at the notches. Corolla bell-shaped, 5-cleft, with 5 double, nectar-bearing folds inside. Stamens projecting, the filaments bearded. Style projecting; ovary covered with bristly hairs, the placentæ very broad and fleshy, inclosing the ovules. Capsule globular, 1–4-seeded.

1. **H. macrophyllum** Nutt. A coarse, rough-hairy plant, about 1 ft. high, from scaly-toothed rootstocks. Leaves oblong, pinnate and pinnately cut, the divisions mucronate, obtuse, coarsely toothed. Flower cluster dense, globular, long-peduncled. Flowers about ½ in. long. Calyx little or not at all appendaged, its lobes broad at the base, but with slender, tapering points. Corolla white. Rich, rocky woods W. and S.

2. **H. virginianum** L. Nearly smooth, 1–2 ft. high, stem often forking at the base. Leaves of the stem mostly near the top, pinnately cut into 5–7 divisions; lobes oval-lanceolate, deeply serrate, the lowest ones distinct; petioles of the basal and lower leaves 4–8 in. long. Flower clusters on peduncles longer than the petioles of the upper leaves, from the axils of which or opposite which they arise. Flowers about ¼ in. long. Calyx not appendaged, its lobes narrowly linear, bristly-margined. Corolla whitish, with purplish veins. Moist woods.

3. **H. appendiculatum** Michx. Hairy, 1–1½ ft. high. Stem leaves palmately 5-lobed, the lobes acute, toothed, lowest ones pinnately divided. Flower cluster rather loose. Calyx appendaged at the notches. Corolla blue. Stamens projecting from the corolla little or not at all. Moist woods.

II. ELLISIA L. (MACROCALYX)

Delicate, branching annuals. Leaves pinnately lobed or divided. Flowers small, whitish. Calyx without appendages, 5-parted, enlarged and leafy in fruit. Corolla bell-shaped or cylindrical, little if any longer than the calyx, 5-lobed, with 5 minute appendages within the tube. Placentæ, fruit, and seeds nearly as in *Hydrophyllum*.

1. **E. Nyctelea** L. Plant somewhat roughish-hairy, 6–12 in. high. Leaves pinnately parted or divided. Peduncles 1-flowered, opposite the leaves. Corolla whitish. Pod globose, finally pendulous. In damp, shady places.

III. PHACELIA Juss.

Herbs, mostly annual. Leaves alternate, sometimes simple, but in most species lobed or divided. Flowers in one-sided clusters, often showy. Calyx 5-parted, without appendages. Corolla with 5 spreading lobes. Ovary 1-celled, with narrow placentæ.

1. **P. bipinnatifida** Michx. A hairy biennial. Stem upright, 1–2 ft. high. Leaves on long petioles, pinnately divided or deeply cut into 3–7 toothed or cut segments. Racemes long, loose, many-flowered. Flowers blue or violet, the spreading or recurved pedicels about as long as the calyx. Calyx segments linear. Corolla broadly bell-shaped, its appendages in pairs between the stamens. Rich soil in thickets and along streams.

2. **P. tanacetifolia** Benth. A tall, hairy annual. Leaves pinnately cut. Spikes long, densely flowered. Flowers showy, blue. Stamens projecting. Capsule 4-seeded. Cultivated from California.

3. **P. Whitlavia** Gray. WHITLAVIA. A rather coarse, sticky annual. Leaves broad, ovate, coarsely toothed, petioled. Flower clusters a loose raceme. Flowers showy, about 1 in. long, blue or sometimes white. Corolla bell-shaped. Stamens and style projecting. Capsule many-seeded. Cultivated from California.

4. **P. linearis** Holz. EUTOCA. A much-branched, somewhat rough or rough-hairy plant, 3–12 in. high. Leaves linear or lanceolate, entire or nearly so. Flowers showy, violet or white, loosely panicled. Capsule many-seeded. Cultivated from California.

86. BORAGINACEÆ. BORAGE FAMILY

Mostly herbs, with stems and foliage roughened with stiff hairs. Leaves alternate and entire, not aromatic. Flowers generally in a coiled inflorescence. Calyx 5-parted. Corolla hypogynous, generally 5-lobed and regular. Stamens 5, inserted on the corolla tube. Style 1; ovary commonly 4-lobed, ripening into 4 1-seeded nutlets.

I. HELIOTROPIUM L.

Herbs or low shrubs. Leaves petioled. Flowers white, blue, or lilac, in one-sided, curved spikes. Calyx 5-parted. Corolla salver-shaped, the throat open. Anthers almost sessile. Style short; stigma conical or knobbed. Fruit separating into 2 or 4 nutlets.

1. **H. peruvianum** L. Common Heliotrope. Somewhat shrubby, much branched. Leaves lance-ovate or somewhat oblong, veined and much wrinkled, short-petioled. Flowers numerous, in a cluster of terminal spikes, bluish-purple or lavender, very sweet-scented, the odor not unlike that of vanilla. Cultivated from Peru.

II. CYNOGLOSSUM L.

Coarse, rough-hairy or silky biennials. Flowers small, bluish-purple or white, in forked and usually bractless cymes. Calyx 5-parted. Corolla funnel-shaped, the mouth closed by prominent scales, its lobes obtuse. Stamens not projecting. Styles stiff, persistent. Nutlets 4, covered with hooked or barbed bristles, attached to a thickened, conical receptacle.

1. **C. officinale** L. Hound's-Tongue, Sheep Lice, Dog Bur, Stick-Tights. Stem 1–2 ft. high, soft-downy, panicled above. Basal leaves 8–10 in. long, long-petioled, oblong or oblong-lanceolate; stem leaves sessile, linear-oblong or lanceolate, rounded or heart-shaped at the base. Corolla ½ in. in diameter, reddish-purple. Nutlets ¼ in. long, with a thickened border. Whole plant with a strong smell like that of mice. A troublesome weed; along roadsides and in pastures; naturalized from Europe.

2. **C. virginianum** L. Wild Comfrey. Perennial. Stem stout, simple, erect, leafless above, 2–3 ft. high. Leaves oval or oblong, the upper clasping by a heart-shaped base. Racemes bractless; flowers pale blue, on short pedicels, which are recurved in fruit. Nutlets not margined, separating and falling away at maturity. On dry soil.

III. LAPPULA Moench.

Annual or biennial herbs, grayish, with rough hairs. Flowers small, blue or whitish, racemed or spiked. Corolla salver-shaped, its throat closed with 5 concave scales. Nutlets more or less covered with prickles, which are barbed at the tip, attached by their sides to the base of the style.

1. **L. virginiana** Greene. Beggar's Lice. A coarse biennial, 2–4 ft. high, the stem much branched above. Basal leaves roundish-ovate or heart-shaped, on slender petioles; stem leaves 3–4 in. long, pointed at both ends. Racemes 1–3 in. long, terminating the slender, spreading branches; flowers small, bluish-white. Fruit forming a troublesome bur. Fence rows and thickets.

IV. MYOSOTIS L.

Low, annual, biennial, or perennial herbs; stems branching, erect, or diffuse. Leaves alternate, entire. Flowers small, blue, pink, or white, in elongated, bractless racemes. Calyx 5-cleft, the lobes erect or spreading in fruit. Corolla salver-form, 5-lobed, the tube as long as the calyx, the throat with 5 small appendages. Stamens 5, inserted in the tube of the corolla, included. Ovary 4-parted; style slender. Nutlets smooth or downy, elliptical, compressed.*

1. M. scorpioides L. Forget-Me-Not. Perennial, from slender rootstocks; stems slender, downy, rooting at the nodes, 6–15 in. long. Leaves oblong to oblong-lanceolate, obtuse, narrowed to the sessile base, appressed-downy. Racemes many-flowered; pedicels becoming elongated in fruit. Lobes of the calyx shorter than the tube, spreading in fruit. Corolla blue, with a yellow eye. Nutlets angled, smooth. In gardens and often naturalized from Europe.*

2. M. laxa Lehm. Small Forget-Me-Not. Annual or perennial; whole plant downy; stem slender, weak, decumbent and rooting at the base, 1–2 ft. long. Lower leaves spatulate, the upper lanceolate. Racemes loosely flowered, becoming elongated in fruit; pedicels spreading. Calyx rough-hairy, the lobes as long as the tube. Corolla pale blue, with a yellow eye. Nutlets convex on all sides. On low ground and in brooks and ponds.*

V. MERTENSIA Roth.

Perennial herbs. Leaves generally pale, smooth, and entire. Calyx short, deeply 5-cleft or 5-parted. Corolla somewhat trumpet-shaped or funnel-shaped, often with 5 small folds or ridges in the throat, between the points of insertion of the stamens. Style long and slender. Nutlets smooth, or at length becoming wrinkled.

1. M. virginica Link. Lungwort, Bluebells. Smooth, nearly erect, 1–1½ ft. high. Basal leaves large, obovate or nearly so, and petioled; stem leaves smaller, sessile. Flowers clustered. Corolla nearly trumpet-shaped, varying with age from lilac to blue (or occasionally white). Stamens with slender filaments projecting beyond the corolla tube. Damp, open woods, and banks of streams; sometimes cultivated.

VI. LITHOSPERMUM L.

Herbs, with stout, usually reddish roots. Flowers appearing axillary and solitary or else in leafy-bracted spikes. Corolla funnel-shaped or salver-shaped, with or without folds or appendages at the mouth of the tube; the limb 5-cleft, its divisions rounded. Stamens included in the corolla tube, the anthers nearly sessile. Nutlets either smooth or wrinkled, generally very hard and bony.

1. **L. arvense** L. Corn Gromwell. A rough weed, about 1 ft. high. Leaves narrowly lanceolate. Flowers inconspicuous, whitish, in the upper leaf axils. Corolla hardly extending beyond the calyx, without appendages in the throat. Nutlets rough or wrinkled and dull. Sandy banks and roadsides; naturalized from Europe.

2. **L. Gmelini** Hitchc. Hairy Puccoon. Rough-hairy, perennial, 1–2 ft. high. Corolla deep orange-yellow, with appendages in the throat and clad with wool within at the bottom; flowers handsome, peduncled, in a crowded cluster. Dry, open pine woods, in sandy soil.

3. **L. canescens** Lehm. Puccoon, Indian Paint. Perennial; clothed with soft hairs, 8–12 in. high. Flowers axillary and sessile. Corolla appendaged, not woolly within, showy, orange-yellow. Banks and open woods.

4. **L. angustifolium** Michx. Narrow-leaved Puccoon. Perennial; rough, 6–18 in. high, from a deep root. Leaves linear, sessile, acute or nearly so. Flowers pediceled in terminal leafy racemes of two kinds, the earlier showy, bright yellow, with a corolla tube an inch or more long; the latter much smaller, pale yellow, cleistogamous, fruiting abundantly. Pedicels of the cleistogamous flowers at length recurved. Nutlets ovoid, white, very smooth, slightly pitted. In dry soil W.

VII. ONOSMODIUM Michx.

Mostly rough-hairy perennial herbs. Leaves sessile, entire, with prominent veins. Flowers rather small, white, greenish or yellowish, in leafy one-sided spikes or racemes. Calyx 5-parted into linear divisions. Corolla tubular or tubular-funnelform, with 5 acute erect lobes. Stamens 5, perigynous, not projecting from the corolla tube. Style thread-like, decidedly projecting. Nutlets usually only 1 or 2, white, smooth and shining.

1. **O. virginianum** A.DC. Stems rather slender, 1–3 ft. high, covered with rough, stiff bristles. Leaves oblong or oblong-lanceolate,

the lower ones narrowed at the base. Corolla narrow, its lobes lance-awl-shaped, slightly bearded outside with long bristles. In dry thickets or on hillsides.

2. O. **hispidissimum** Mackenzie. Stem stout, upright, 1–4 ft. high, shaggy with long bristly hairs. Leaves from lanceolate to oblong, acute, 2–4½ in. long. Corolla rather broad, its lobes ovate-triangular or triangular-lanceolate, thickly hairy outside. Nutlets with a very short neck at the base. Rich soil along river banks and bottom lands.

VIII. ECHIUM L.

Herbs or sometimes shrubs, usually stout, coarse, and hairy. Leaves entire. Flowers white, reddish-purple or blue, in spiked or panicled racemes. Calyx 5-parted. Corolla tube cylindrical or funnel-shaped; the throat dilated; the limb with 5 unequal lobes. Filaments unequal, attached to the corolla below, projecting from the corolla. Style thread-like; stigma 2-lobed. Nutlets 4, ovoid or top-shaped, wrinkled.

1. **E. vulgare** L. Blue Thistle, Blue Weed, Blue Devils. Stems 1–3 ft. high, more or less erect, leafy, covered with stinging hairs. Root leaves lanceolate or oblong, petioled, 4–8 in. long; stem leaves sessile, acute, rounded at the base. Flowers showy, reddish-purple in the bud, changing to bright blue. A very troublesome weed, especially in fallow fields. Naturalized from Europe.

87. VERBENACEÆ. Verbena Family

Herbs, shrubs, or trees. Leaves opposite or whorled, without stipules. Flowers zygomorphic, in bracted cymes. Calyx hypogynous, cleft or toothed. Corolla hypogynous, tubular, usually more or less 2-lipped. Stamens usually 4 (2 long and 2 short), inserted on the corolla tube. Ovary usually 2–4-celled (in *Phryma* 1-celled), with the style springing from its summit.

I. VERBENA L.

Annual or perennial herbs. Leaves simple, opposite, serrate or pinnately lobed. Flowers in terminal spikes which become much elongated in fruit. Calyx tubular, 5-ribbed, 5-toothed. Corolla salverform or funnelform, the tube often curved, bearded in the throat, limb spreading, 5-lobed, often somewhat 2-lipped. Stamens 4 (2 long and 2 short), rarely only 2, included. Ovary 2–4-celled, 2–4-ovuled; style slender, 2-lobed. Fruit 2–4 smooth or roughened, 1-seeded nutlets. [Several of the commonest species are tall, coarse herbs, which blossom too late for school study.]*

1. V. officinalis L. EUROPEAN VERVAIN. Annual; stem erect, slender, nearly or quite smooth, branching, 1–3 ft. high. Leaves ovate to obovate in outline, pinnately lobed or divided, narrowed and entire toward the base, downy beneath; petioles margined. Spikes several, very slender; flowers small, purple; bracts shorter than the calyx. In fields and waste places. Naturalized from Europe.*

2. V. angustifolia Michx. NARROW-LEAVED VERVAIN. Perennial, rough-hairy; stem simple, or branched below, from a creeping base, 1–2 ft. high. Leaves lanceolate to spatulate, obtuse and toothed at the apex, tapering to a sessile base. Spike peduncled, slender, close-flowered; bracts about the length of the calyx. Corolla purple, tube slightly curved, $\frac{1}{4}$ in. long. In dry, open woods.*

3. V. bracteosa Michx. Perennial; widely spreading or decumbent, hairy; stems 6–15 in. long, 4-sided, branching from the base. Leaves wedge-lanceolate, 3-cleft or pinnately cut, short-petioled. Spikes sessile, stout, with large bracts, the lower ones pinnately cut and longer than the flowers. Flowers small, purple. On prairies and waste ground.

4. V. bipinnatifida Nutt. Perennial; plant rough-hairy, producing suckers, erect, 6–18 in. high. Leaves with petioles, or the upper ones sessile, once or twice pinnately parted into oblong or linear divisions. Spikes stout, dense and solitary at the ends of the branches; bracts usually longer than the calyx. Corolla bluish-purple or lilac, less than $\frac{1}{2}$ in. in diameter. Dry plains and prairies W. and S.

5. V. canadensis Britton. WILD VERBENA. A slender-stemmed, somewhat reclining annual, 1 ft. or less in height. Leaves ovate or nearly so, wedge-shaped at the base, lobed and toothed or 3-cleft. Flowers showy, reddish-purple or lilac (seldom white), in a peduncled spike. Calyx teeth as long as or longer than the bracts. Corolla very slightly bearded in the throat. In dry prairie soil and open woods; also cultivated. [Other somewhat similar cultivated species are from Brazil.]

II. CALLICARPA L.

Shrubs. Leaves simple, petioled, opposite or whorled, glandular-dotted. Flowers in axillary cymes. Calyx 4-toothed or entire. Corolla funnelform, 4-cleft, actinomorphic. Stamens 4, equal, projecting. Ovary 4-ovuled; style slender; stigma knobbed. Fruit a 1–4-seeded berry.*

1. C. americana L. French Mulberry, Mexican Mulberry. Shrubs, with star-shaped glandular or scurfy down, widely branched, 3–8 ft. high. Leaves ovate to oblong, acute at each end, crenate-serrate, rough above, downy beneath, glandular-dotted; petioles slender. Cymes many-flowered, the peduncle as long as the petiole; pedicels short. Calyx cup-shaped, the teeth short. Corolla double the length of the calyx, blue. Fruit violet-purple, very conspicuous in autumn. Common in fields and thickets S.*

88. LABIATÆ. Mint Family

Mostly herbs, with square stems and opposite, more or less aromatic, leaves, without stipules. Flowers generally in cyme-like axillary clusters, which are often grouped into terminal spikes or racemes. Calyx tubular, usually 2-lipped, persistent. Corolla usually 2-lipped. Stamens 4 (2 long and 2 short) or only 2. Ovary free, with 4 deep lobes, which surround the base of the style. Fruit consisting of 4 nutlets, ripening inside the base of the calyx.

A

Stamens 4.

(*a*) Calyx 2-lipped.

Lips entire. Scutellaria, I

Lips toothed and cleft. Plants not aromatic. Prunella, IV

Lips toothed and cleft. Plants aromatic. Leaves extremely small. Thymus, IX

(*b*) Calyx not 2-lipped, or not much so.

Calyx tubular, 5–10-toothed. Stamens not projecting from tube of corolla. Marrubium, II

Calyx tubular, with 5 equal teeth. Stamens under upper lip of corolla. Nepeta, III

Calyx tubular, bell-shaped, with 5 awl-shaped teeth. Stamens not turned down after maturing. Lamium, V

Calyx top-shaped, with spreading spiny teeth. Leonurus, VI

Calyx as in V. Stamens turned down after maturing. Stachys, VII

B

Stamens 2. Salvia, VIII

I. SCUTELLARIA L.

Mostly slender herbs, not aromatic. Flowers solitary or in pairs, axillary or in terminal spikes or racemes. Calyx bell-shaped, 2-lipped, the upper part swollen into a helmet-shaped pouch; mouth of the calyx closed after flowering. Corolla tube long, naked inside. Stamens 4, the anthers meeting in pairs, hairy-fringed. Style with a very short upper lobe. [The species here described are not the commonest ones, but most of the others grow in damp soil and bloom later.]

1. S. serrata Andr. Skullcap. Stem not much branched, 1–3 ft. high. Stem leaves serrate, taper-pointed at both ends, ovate or nearly so. Racemes single, loose. Calyx rather hairy. Corolla 1 in. long, the lips of equal length. Woods.

2. S. pilosa Michx. Hairy Skullcap. Stem more or less hairy, not much if at all branched, 1–3 ft. high. Leaves a few distant pairs, diamond-ovate, oblong-ovate, or roundish-ovate, scalloped, obtuse, the lower heart-shaped or nearly truncate at the base, with long petioles. Racemes short, few-flowered. Corolla $\frac{1}{2}$ in. long; tube whitish, lips blue, the lower one rather shorter. Open woodlands and dry soil.

3. S. integrifolia L. Large-flowered Skullcap. Stem covered with fine, grayish down, usually unbranched, 1–2 ft. high. Leaves lance-oblong or nearly linear, mostly entire, obtuse, with very short petioles. Corolla 1 in. long, tube pale, lips large and spreading, blue. Dry ground.

4. S. parvula Michx. Small Skullcap. Perennial with necklace-like tuber-bearing rootstocks. Stems slender, minutely downy, 3–12 in. long, erect or spreading. Leaves varying from ovate to lanceolate, or the lower nearly round. Flowers solitary in the axils of the upper leaves. Corolla $\frac{1}{6}$–$\frac{1}{3}$ in. long, violet, downy. In moist, sandy soil.

II. MARRUBIUM L.

Perennial, downy, or woolly herbs. Whorls of flowers axillary; flowers small; bracts leaf-like. Calyx tubular, 5–10-toothed; teeth somewhat spiny. Corolla short; upper lip erect, lower spreading, 3-cleft, the middle lobe broadest. Stamens 4, not projecting. Lobes of the stigma short and blunt.

1. M. vulgare L. Horehound. Stems somewhat reclining, stout, branching, leafy, 1–1$\frac{1}{2}$ ft. high. Leaves broadly ovate, heart-shaped or wedge-shaped at the base, scalloped, leathery and wrinkled. Whorls of flowers dense. Calyx teeth hooked at the tip. Corolla $\frac{1}{2}$ in. long, white. Cultivated from Europe as an herb (used in preparation of horehound candy) and somewhat naturalized.

III. NEPETA L.

Erect or prostrate herbs. Whorls of flowers axillary or terminal; flowers blue or white. Calyx tubular, 15-ribbed, 5-toothed. Corolla tube slender below, dilated at the throat, naked; upper lip notched or 2-cleft; lower lip 3-cleft, middle lobe large. Stamens 4, ascending under the upper lip, the upper pair longer. Lobes of the stigma awl-shaped.

B. Fl. species 2 (*Glecoma*).

1. N. Cataria L. CATNIP. Stem grayish, downy, 2–3 ft. high, branched, very leafy. Leaves large, ovate-heart-shaped, deeply scalloped, serrate, white and downy beneath. Corolla about $\frac{1}{2}$ in. long, whitish with purple dots. Naturalized from Europe; a common weed about dooryards.

2. N. hederacea Trevisan. GROUND IVY, GILL-OVER-THE-GROUND, CREEPING CHARLEY, CROW VICTUALS, ROBIN RUNAWAY. Creeping. Leaves roundish, kidney-shaped, and crenate. Corolla bluish-purple, three times as long as the calyx. Common in damp places about houses and gardens. Naturalized from Europe.

IV. PRUNELLA L.

Perennials, with stems simple or nearly so, and sessile, 3-flowered flower clusters in the axils of kidney-shaped bracts, the whole forming a spike or head. Calyx tubular-bell-shaped, somewhat 10-ribbed; upper lip broad, 3-toothed, the teeth short; lower lip with 2 longer teeth. Upper lip of the corolla upright, arched, and entire; the lower spreading, reflexed, fringed, and 3-cleft. Stamens 4, reaching up under the upper lip, with the tips of the filaments 2-toothed; only one tooth anther-bearing.

1. P. vulgaris L. SELF-HEAL, HEALALL, CARPENTER WEED. Leaves with petioles, ovate-oblong, either entire or toothed, often somewhat hairy. Corolla usually blue or bluish, somewhat longer than the brown-purple calyx. Open woods and fields everywhere.

V. LAMIUM L.

Annual or perennial hairy herbs. Calyx tubular-bell-shaped, 5-veined, with 5 awl-pointed teeth of nearly equal length.

Corolla with dilated throat, upper lip arched, middle lobe of the lower lip notched, the lateral lobes small, close to the throat of the corolla. Stamens 4, rising beneath the upper lip.

1. L. amplexicaule L. HENBIT, DEAD NETTLE. An annual or biennial weed. Leaves roundish, deeply scalloped, the lower ones petioled, the upper sessile and clasping. Corolla sometimes $\frac{3}{4}$ in. long, downy, rose-colored or purplish. Not uncommon about gardens and dooryards. Naturalized from Europe.

2. L. purpureum L. Stem 6–18 in. high, silky-hairy or nearly smooth, reclining below, branched from the base. Leaves long-petioled, obtuse, heart-shaped, scalloped. Whorls of flowers mostly terminal, crowded. Corolla $\frac{1}{2}$–$\frac{3}{4}$ in. long, purple (rarely white). Naturalized from Europe.

VI. LEONURUS L.

Erect herbs. Leaves lobed. Whorls of flowers axillary, densely flowered, scattered; bractlets awl-shaped; flowers small, pink or white. Calyx 5-nerved, top-shaped, with 5 rather spiny, spreading teeth. Corolla with upper lip erect and entire, lower 3-cleft. Stamens 4; anthers joined in pairs. Nutlets with 3 projecting angles, their sides channeled.

1. L. cardiaca L. MOTHERWORT. Stem 2–4 ft. high, prominently angled, stiff, stout, upright, very leafy. Leaves palmately lobed or cleft; basal ones long-petioled; lower stem leaves many-cleft, the upper ones 3-cleft, prominently nerved, the divisions acute. Corolla $\frac{1}{2}$ in. long, pale rose color, the upper lip and outside of the tube densely soft-bearded. Common about dooryards and fence rows. Naturalized from Europe.

VII. STACHYS L.

Herbs, rarely shrubs. Leaves scalloped or serrate. Whorls of flowers 2 or more flowered, usually in terminal racemes. Calyx nearly bell-shaped, 5-toothed. Corolla tube cylindrical, usually with a ring of hairs inside, not dilated at the throat; upper lip erect or spreading; lower spreading, 3-lobed, the middle lobe largest. Stamens 4, the 2 lower longest.

1. S. palustris L. Perennial; stem erect, 4-angled, 2–3 ft. high, hairy, especially on the angles, with projecting or reflexed hairs, leafy. Stem leaves short-petioled or sessile, ovate-lanceolate or oblong-lanceolate, scalloped-serrate, coarsely or finely downy, roundish at the base, rather obtuse at the tip. Calyx bristly, the lance-awl-shaped teeth rather spiny. Upper lip of the corolla downy. In wet soil, especially N.

2. S. tenuifolia Willd., var. **aspera**. Taller than No. 1; angles of the stem covered with stiff reflexed bristles, but the sides often smooth. Leaves serrate, nearly all with distinct petioles. Calyx usually smooth. Corolla smooth throughout. Damp thickets and along streams.

VIII. SALVIA L.

Annual, biennial, or perennial herbs, or sometimes shrubby. Flowers in spikes, racemes, or panicles, usually showy. Calyx tubular or bell-shaped, not bearded in the throat, 2-lipped, the upper lip entire or 3-toothed, the lower 2-cleft. Corolla 2-lipped; the upper lip entire or notched, the lower spreading, 3-lobed, with the middle lobe longer. Stamens 2, short; anthers 2-celled, the upper cell fertile, the lower imperfect. Style 2-cleft. Nutlets smooth.*

1. S. lyrata L. Lyre-leaved Salvia. Biennial or perennial; stem erect, sparingly branched above, rough-hairy, 1–2 ft. high. Leaves mostly basal, spreading, lyrate-pinnatifid, usually purple; stem leaves small, sessile or short-petioled. Racemes many-flowered, whorls about 6-flowered. Calyx teeth short on the upper lip, long and awl-shaped on the lower. Corolla blue or purple; the tube about 1 in. long, dilated upward. On dry soil.*

2. S. officinalis L. Garden Sage. Stem shrubby, slender, much branched below, 1 ft. high. Leaves grayish-green, lance-oblong, crenate, wrinkled. Flowers in terminal spikes, whorls several-flowered. Corolla blue, upper lip strongly arched, about equaling the lower. A common garden herb. Cultivated from Europe.*

IX. THYMUS L.

Small, much-branched shrubs, very aromatic. Leaves small, entire, margins often rolled under. Whorls of flowers few-flowered, in loose or close spikes; bracts very small; flowers usually purple. Calyx ovoid, 2-lipped; upper lip 3-toothed; lower 2-cleft, woolly in the throat. Corolla slightly 2-lipped. Stamens 4, usually projecting from the flower, straight; lower pair longer.

1. T. Serpyllum L. Creeping Thyme. Smooth or hairy, stem prostrate, the flowering branches somewhat ascending. Leaves $\frac{1}{8}$–$\frac{1}{4}$

in. long, flat, ovate or obovate-lanceolate, obtuse. Flowers crowded in spikes at the end of the branches. Corolla rose-purple, $\frac{1}{4}$–$\frac{3}{4}$ in. long. Naturalized from Europe.

2. T. vulgaris L. GARDEN THYME. More erect than No. 1. Leaves somewhat curled under at the edges. Flower clusters shorter and not all terminal. Corolla pale purple. Cultivated from Europe as an herb.

89. SOLANACEÆ. NIGHTSHADE FAMILY

Mostly tropical herbs or shrubs (rarely trees). Leaves usually alternate, without stipules. Flowers actinomorphic, borne on bractless pedicels at or above the leaf axils, or in cymes. Calyx hypogynous, 5-cleft, usually persistent. Corolla hypogynous, wheel-shaped, bell-shaped, or salver-shaped, 5-lobed. Stamens 5, short, inserted on the corolla tube. Ovary 2-celled or imperfectly 4-celled; style simple; stigma simple or lobed. Fruit a many-seeded capsule or berry.

I. SOLANUM L.

Herbs or shrubs; stems often prickly, sometimes climbing. Leaves alternate, often nearly or quite opposite. Flowers clustered, the peduncles often opposite or above the axils. Calyx spreading, 5-toothed or 5-cleft, persistent. Corolla wheel-shaped, 5-lobed. Stamens 5, projecting, the filaments very short, the anthers long and meeting about the style. Ovary 2-celled; style slender. Fruit a many-seeded, juicy berry.*

1. S. Dulcamara L. BITTERSWEET. Perennial; stems rather shrubby, long, and climbing. Leaves heart-shaped, or some of them with irregular lobes, or ear-like leaflets at the base. Flowers blue or purple, somewhat cymose. Berries showy, of many shades of orange and red in the same cluster, according to their maturity. Naturalized from Europe.

2. S. nigrum L. NIGHTSHADE. Annual; stem smooth, or downy with simple hairs, erect, diffusely branched; branches wing-angled, 1–3 ft. high. Leaves ovate, irregularly toothed or entire, somewhat inequilateral, petioled. Flowers in lateral, peduncled umbels, small, white, drooping. Calyx lobes obtuse; corolla $\frac{1}{3}$–$\frac{1}{2}$ in. wide; filaments downy; berries globose, smooth, black when ripe. Common in cultivated fields and waste places.*

3. S. carolinense L. HORSE NETTLE. Perennial; stem erect, branched, downy with star-shaped hairs, armed with straight yellow prickles, 1–3 ft. high. Leaves ovate-oblong, deeply toothed or lobed, acute at the apex, abruptly contracted to the short petiole, prickly on the veins. Racemes lateral, few-flowered; pedicels recurved in fruit. Calyx lobes taper-pointed. Corolla deeply angular-lobed, blue or white; berry globose, smooth, yellow. A common weed.*

4. S. rostratum Dunal. SAND BUR, BUFFALO BUR. Annual; the whole plant beset with yellow prickles; stem erect, diffusely branched, 1–2 ft. high. Leaves broadly oval or ovate in outline, deeply pinnately lobed or parted, petioled, downy with star-shaped hairs. Racemes few-flowered; pedicels erect in fruit. Calyx very prickly, becoming enlarged and inclosing the fruit. Corolla bright yellow, 5-angled, about 1 in. broad. From the West, becoming a troublesome weed in some places.*

5. S. tuberosum L. IRISH POTATO. Annual; stem diffusely branched, downy, underground branches numerous and tuber-bearing. Leaves irregularly pinnatifid and divided. Flowers in cymose clusters, white or purple, with prominent yellow anthers; pedicels jointed. Corolla 5-angled, $\frac{3}{4}$–1 in. broad. Fruit a globose, greenish-yellow, many-seeded berry, about $\frac{1}{2}$ in. in diameter. Cultivated from Chile.*

II. LYCOPERSICUM Hill.

Annual; stem diffusely branched. Leaves pinnately divided. Flowers in raceme-like clusters on peduncles opposite the leaves. Calyx 5–many-parted, persistent. Corolla wheel-shaped, 5–6-parted. Stamens 5–6, inserted in the short tube of the corolla; filaments short, anthers elongated. Ovary 2–several-celled; style and stigma simple. Fruit a many-seeded berry.*

1. L. esculentum Mill. TOMATO. Stem diffusely branched, at length leaning over, furrowed and angled below, sticky-hairy, 3–5 ft. long. Leaves irregularly lobed and pinnatifid, petioled. Calyx lobes linear, about as long as the yellow corolla. Fruit (in the wild state) globose or ovoid, red or yellow, $\frac{1}{4}$–$\frac{1}{2}$ in. in diameter, but greatly enlarged in cultivation. Common in cultivation from tropical America.*

III. LYCIUM L.

Shrubs or woody vines, often spiny. Leaves entire, alternate, often fascicled. Flowers solitary or clustered, terminal or axillary. Calyx persistent, 4–5-lobed or toothed, not enlarged in fruit. Corolla funnelform or bell-shaped, the limb 4–5-lobed, the lobes obtuse. Stamens 4–5, projecting. Ovary 2-celled; style single; stigma obtuse. Fruit a many-seeded berry.*

1. **L. halimifolium** Mill. MATRIMONY VINE. Stem slender, branching, twining or trailing, 6–15 ft. long; branches angled, spiny. Leaves elliptical, smooth, entire, sessile or short-petioled. Flowers solitary or few in the axils; peduncles long and slender. Corolla spreading, greenish-purple, $\frac{1}{3}$–$\frac{1}{2}$ in. wide. Berry oval, orange-red. Introduced from Africa, and often planted for covering trellises.*

IV. DATURA L.

Annual or perennial, strong-scented herbs; stems tall and branching. Leaves petioled, entire or lobed. Flowers large, solitary in the forks of the branches. Calyx tubular, 5-toothed or lobed, the upper part deciduous and the lower persistent. Corolla funnelform, 5-angled. Stamens 5, inserted in the corolla tube. Ovary 2-celled or imperfectly 4-celled; style filiform; stigma 2-lobed. Fruit a spiny, 4-valved, many-seeded capsule.*

1. **D. Stramonium** L. JIMSON WEED. Annual; stem smooth, green, stout, forking above, 1–4 ft. high. Leaves ovate to oblong-ovate, acute at the apex, narrowed at the base, sinuate-toothed, petioled. Calyx 5-angled. Corolla white, about 4 in. long. Capsule ovoid, erect, 2 in. long. A common weed; poisonous. Naturalized from Asia (?).*

2. **D. Tatula** L. Taller, with a purple stem; flowers rather later than No. 1. Corolla violet-tinged. Naturalized from tropical America.

V. PETUNIA Juss.

Herbs; leaves alternate and entire. Divisions of the calyx oblong-spatulate. Corolla showy, spreading, funnel-shaped, not perfectly actinomorphic. Stamens 5, somewhat unequal in length, inserted in the middle of the corolla tube and not projecting beyond it. Capsule 2-celled, containing many very small seeds.

1. **P. violacea** Lindl. COMMON PETUNIA. Stems rather weak and reclining. Leaves covered with clammy down. Corolla varying from pale pink to bright purplish-red, often variegated, with a broad, inflated tube, which is hardly twice as long as the calyx. Cultivated annual from South America.

2. P. nyctaginiflora Juss. White Petunia. Leaves somewhat petioled. Tube of corolla long and slender. Flowers white. Cultivated from South America. This and the preceding species much mixed by hybridization.

90. SCROPHULARIACEÆ. Figwort Family

Mostly herbs, with flowers not actinomorphic. Calyx free from the ovary and persistent. Corolla often 2-lipped. Stamens usually 2 long and 2 short, or only 2 in all, inserted on the corolla tube, often 1 or 3 of them imperfectly developed. Pistil consisting of a 2-celled and usually many-ovuled ovary, with a single style and an entire or 2-lobed stigma.

Corolla wheel-shaped, stamens 5. Verbascum, I

Corolla wheel-shaped or salver-shaped, nearly actinomorphic, stamens 2. Veronica, VI

Corolla 2-lipped, the mouth closed by a palate, tubular below, a spur at the base. Linaria, II

Corolla 2-lipped, the mouth closed by a palate, tubular below, a short, broad pouch at the base. Antirrhinum, III

Corolla decidedly 2-lipped.

Stamens with anthers 2. Gratiola, V

Stamens 4, with a fifth antherless filament. Pentstemon, IV

Stamens 4, the anther cells unequal. Castilleja, VII

Stamens 4, the anther cells equal. Pedicularis, VIII

I. VERBASCUM L.

Biennial; stem tall, erect. Leaves alternate. Flowers in spikes, racemes, or panicles. Calyx deeply 5-cleft. Corolla wheel-shaped, 5-lobed, the lobes nearly equal. Stamens 5, unequal, declined; some or all of the filaments bearded. Style flattened at the apex. Fruit a globose capsule; seeds roughened.*

1. V. Blattaria L. Moth Mullein. Stem erect, slender, simple or sparingly branched, smooth below, downy above, 2–4 ft. high. Leaves oblong to lanceolate, acute at the apex, obtuse or truncate at the base, dentate to pinnately lobed, the lower petioled, the upper sessile and clasping. Raceme long and loose, glandular-downy; pedicels bracted. Corolla white or yellow, marked with brown on the back, about 1 in. wide. Filaments all bearded with purple hairs. Capsule longer than the calyx. Common in fields and waste places. Naturalized from Europe.*

II. LINARIA Hill

Herbs, rarely shrubby. Lower leaves opposite, whorled or alternate. Flowers in bracted racemes or spikes, or axillary and solitary. Calyx 5-parted. Corolla 2-lipped, the tube spurred. Stamens 4, with sometimes a rudiment of a fifth. Stigma notched or 2-lobed. Capsule ovoid or globose; cells nearly equal.

1. **L. vulgaris** Hill. Butter and Eggs, Jacob's Ladder, Wild Flax. A perennial, erect, smooth herb, with a bloom; stem 1–2 ft. high. Leaves linear or lanceolate, 1–3 in. long, often whorled. Racemes densely flowered. Sepals shorter than the spur. Corolla yellow, $\frac{3}{4}$–1 in. long; spur parallel to and as long as the tube; throat closed by a palate-like fold. Common in dry fields and pastures and along roadsides. Naturalized from Europe.

2. **L. canadensis** Dumont. Toadflax. Biennial; flowering stems erect, slender, rarely branched, smooth, 1–2 ft. high; sterile stems prostrate, with opposite or whorled leaves, 2–6 in. long. Leaves linear, entire, sessile. Racemes erect, slender; pedicels erect, as long as the calyx. Corolla small, blue and white, the spur thread-like, curved, longer than the pedicels. Capsule 2-valved, the valves 3-toothed. On dry or cultivated ground E.

III. ANTIRRHINUM L.

Annual or perennial herbs. Leaves entire, rarely lobed, the lower ones opposite, the upper alternate. Flowers axillary and solitary, or racemed and bracted. Calyx 5-parted. Corolla 2-lipped; the tube with a sac, the broad-bearded palate closing the throat. Stamens 4. Stigma with 2 short lobes. Capsule 2-celled, the upper cell opening by 1 pore, the lower by 2.

1. **A. majus** L. Snapdragon. Perennial; stem erect, smooth below, glandular-downy above, 1–2 ft. high. Leaves linear to oblong-lanceolate, entire, smooth, sometimes fleshy, sessile or short-petioled. Flowers in a terminal raceme; pedicels short, stout, erect in fruit. Corolla $1\frac{1}{2}$–2 in. long, of many colors. Capsule oblique, the persistent base of the style bent forward. Common in gardens; cultivated from Europe, and often escaped.*

IV. PENTSTEMON Mitchell

Perennials, the stems branching from the base, unbranched above. **Leaves** opposite. Flowers usually showy, in a terminal panicle. Calyx of 5 nearly distinct sepals. Corolla tubular, the tube wide above and narrowed below; 2-lipped. Stamens 4 (2 long and 2 short), with a fifth antherless filament as long as the others, its upper half bearded. Capsule ovoid, acute.

1. P. hirsutus Willd. Stem somewhat sticky-downy, 1–2 ft. high. Leaves varying from oblong to lanceolate, 2–4 in. long, usually with small teeth. Flower cluster narrow. Corolla dingy violet, purplish, or whitish; the tube not much widened above, its throat nearly closed by a hairy palate. Sterile filament much bearded. Dry hillsides or stony ground.

2. P. gracilis Nutt. SLENDER BEARDTONGUE. Stem 6–18 in. high, smooth below but the flower cluster covered with glandular, sticky hairs. Basal leaves spatulate or oblong; stem leaves most of them linear-lanceolate. Corolla purple or whitish, $\frac{3}{4}$–1 in. long, the tube enlarged above and its throat entirely open. Sterile filament bearded above along half its length. On moist prairies W.

3. P. lævigatus Ait. Stem usually smooth except the flower cluster, 2–4 ft. high. Leaves shining, those of the stem ovate-lanceolate or broadly lanceolate, 2–5 in. long, with a somewhat heart-shaped, clasping base. Flower cluster broader than in No. 1. Corolla white or oftener purplish, suddenly widened above, the throat not closed. Sterile filament slightly bearded toward the top. In rich soil.

4. P. Digitalis Nutt. Much resembling No. 3, but taller, sometimes 5 ft. high. Corolla white, the tube abruptly widened. In fields and thickets; sometimes cultivated.

5. P. barbatus Roth. Stems slender and rod-like, 3–4 ft. high. Leaves lanceolate, entire. Flower cluster long and loosely flowered. Flowers showy, drooping. Corolla tube slender, scarlet, somewhat bearded in the throat. Sterile filament beardless. Cultivated from Mexico.

V. GRATIOLA L.

Low herbs, growing in wet or damp ground. Leaves opposite, sessile. Flowers axillary and solitary, peduncled. Calyx 5-parted, usually with 2 bractlets at the base. Corolla somewhat 2-lipped. Perfect stamens 2. Stigma enlarged or 2-lipped. Pod 4-valved, many-seeded.

1. **G. virginiana** L. Stem cylindrical, 4–10 in. long, branching from the base. Leaves $\frac{3}{4}$–$1\frac{1}{2}$ in. long, varying from lance-oblong to spatulate. Corolla pale yellow, tinged with red. Common in muddy soil, along brooksides, etc.

VI. VERONICA L.

Herbs or shrubs. Lower leaves or all the leaves opposite, rarely whorled. Flowers in axillary or terminal racemes, rarely solitary. Calyx usually 4-parted. Corolla wheel-shaped or somewhat bell-shaped; limb usually 4-cleft, spreading, the side lobes commonly narrower. Stamens 2, inserted on the corolla tube at the sides of the upper lobe, projecting. Stigma somewhat knobbed. Capsule generally flattened, often notched at the apex, 2-celled, few–many-seeded.

1. **V. americana** Schwein. BROOKLIME. A perennial, smooth herb, somewhat prostrate below but the upper parts of the stem erect, 8–15 in. high. Leaves 1–2 in. long, lance-ovate or oblong, serrate, short-petioled. Racemes 2–4 in. long, axillary and opposite. Corolla wheel-shaped, blue. Capsule swollen, roundish. Muddy soil about springs and brooks.

2. **V. officinalis** L. COMMON SPEEDWELL, GYPSY WEED. Perennial. Roughish-downy, with the prostrate stems spreading and rooting. Leaves wedge-oblong or nearly so, obtuse, serrate, somewhat petioled. Racemes dense, of many pale bluish flowers. Capsule rather large, inversely heart-shaped and somewhat triangular. Dry hillsides, open woods and fields.

3. **V. serpyllifolia** L. THYME-LEAVED SPEEDWELL. Perennial; smooth or nearly so; branching and creeping below, but with nearly simple ascending shoots, 2–4 in. high. Leaves slightly crenate, the lowest ones petioled and roundish, those farther up ovate or oblong, the uppermost ones mere bracts. Raceme loosely flowered. Corolla nearly white or pale blue, beautifully striped with darker lines. Capsule inversely heart-shaped, its width greater than its length. Damp, grassy ground; a common weed in lawns.

4. **V. peregrina** L. PURSLANE SPEEDWELL. A homely, rather fleshy, somewhat erect-branched annual weed, 4–9 in. high. Lowest leaves petioled, oblong, somewhat toothed; those above them sessile, the uppermost ones broadly linear and entire. Flowers solitary, inconspicuous, whitish, barely pediceled, appearing to spring from the axils of the small floral leaves. Corolla shorter than the calyx. Capsule roundish, barely notched, many-seeded. Common in damp ground, in fields and gardens.

VII. CASTILLEJA Mutis.

Herbs parasitic on the roots of other plants. Leaves alternate; the floral ones usually colored at the tip and more showy than the flowers. Flowers yellow or purplish in terminal leafy spikes. Calyx tubular, flattened, 2–4-cleft. Corolla tube included within the calyx; upper lip of the corolla very long, linear, arched, and inclosing the stamens, 2 of which are long and 2 short. Ovary many-ovuled.

1. **C. coccinea** Sprengel. Scarlet Painted Cup, Paint Brush, Indian Pink, Prairie Fire, Wickakee. A hairy, simple-stemmed herb, annual or biennial. Root leaves clustered, obovate or oblong; stem leaves cut; floral leaves 3–5-cleft and bright scarlet (occasionally yellow) toward the tips, as though dipped in a scarlet dye. Calyx nearly as long as the pale yellow corolla, 2-cleft. The spikes are often very broad, making this one of the most conspicuous of our native flowers. Damp, sandy ground, or on bluffs near streams; sometimes in marshes.

2. **C. sessiliflora** Pursh. Downy Painted Cup. Perennial; stem leafy, 6–15 in. high, covered with ash-colored down. Lowest leaves linear and entire, upper ones usually deeply cleft into narrow segments; floral leaves green, like the upper stem leaves. Calyx lobes more deeply cleft on the lower than on the upper side, linear-lanceolate. Corolla yellowish, nearly 2 in. long; upper lip about twice the length of the lower one. On prairies W. and S.W.

VIII. PEDICULARIS L.

Perennial herbs, with the lower leaves pinnately cut and the floral ones reduced to bracts. Flowers spiked. Corolla markedly 2-lipped; the upper lip much flattened laterally and arched, the lower lip spreading, 3-lobed. Stamens 4, beneath the upper lip. Capsule 2-celled, tipped with an abrupt point, several-seeded.

1. **P. canadensis** L. Common Lousewort. Hairy, with clustered simple stems, 1 ft. high or less. Leaves petioled, the lowermost ones pinnately parted, the others somewhat pinnately cut. Spike short, closely flowered, and leafy-bracted. Calyx split down the front. Corolla greenish-yellow and purplish, with its upper lip hood-like, curved under, and with 2 awl-like teeth near the end. Capsule flat, broadly sword-shaped. Knolls and openings among thickets.

91. BIGNONIACEÆ. Bignonia Family

Trees or shrubs, often twining or climbing, rarely herbs. Leaves usually opposite, without stipules. Flowers showy, zygomorphic. Corolla tubular, with a widened throat and a 5-lobed limb. Stamens usually 2 long and 2 short, or only 2. Ovary free from the calyx, 2-celled or rarely 1-celled, with many ovules. Fruit a capsule ; seeds large, winged.

I. TECOMA Juss.

Woody vines, climbing by aërial rootlets. Leaves compound, odd-pinnate. Flowers large, in terminal clusters. Calyx bell-shaped, unequally 5-toothed. Corolla funnelform, enlarged above the calyx, 5-lobed, slightly 2-lipped. Stamens 4, 2 long and 2 short. Capsule slender, spindle-shaped, slightly compressed contrary to the partition, 2-valved, dehiscent. Seeds winged.*

1. T. radicans Juss. Trumpet Flower, Trumpet Creeper. Stems climbing high by numerous rootlets; bark shreddy. Leaves deciduous, petioled; leaflets 9–11, ovate to ovate-lanceolate, serrate, short-stalked, smooth or slightly downy. Flowers in short, terminal racemes or corymbs. Calyx tubular, $\frac{3}{4}$ in. long. Corolla 2–3 in. long, scarlet without, yellow within, the lobes spreading. Capsule 5–6 in. long, curved, often persistent through the winter. Seeds broadly winged. On borders of fields and in woods S.; often cultivated.*

II. CATALPA Scop.

Small trees. Leaves large, opposite, simple, petioled, deciduous. Flowers large and showy, in terminal panicles. Calyx irregularly 2-lipped. Corolla tubular-bell-shaped, oblique, 5-lobed, 2-lipped. Fertile stamens 2, sterile stamens 3, short. Fruit a linear, 2-valved, many-seeded capsule. Seeds winged.*

1. C. bignonioides Walt. Catalpa. A small tree with thin, rough gray bark, and light, soft but exceedingly durable wood. Leaves long-petioled, heart-shaped, entire or palmately 3-lobed, taper-pointed at the apex, palmately veined, downy. Branches of the panicle in threes; flowers large, 1–1$\frac{1}{2}$ in. long, white, variegated with yellow and purple. Corolla lobes undulate or crisped. Capsule very slender, 1 ft. or more in length, pendulous. Seeds with long fringed wings. On margins of rivers and swamps S.; often cultivated.*

2. C. speciosa Warder. CATALPA. A tall tree with very durable wood. Leaves large, heart-shaped, taper-pointed. Corolla about 2 in. long, almost white, but slightly spotted; tube inversely conical; limb somewhat oblique, its lower lobe notched. Pod rather stout. Rich, damp woods, especially S. W.; often cultivated.

III. BIGNONIA L.

Woody vines. Leaves opposite, compound, usually tendril-bearing. Flowers large, in axillary clusters. Calyx cup-shaped, truncate, or undulate-toothed. Corolla spreading-tubular, somewhat 2-lipped, the lobes rounded. Stamens 4, 2 long and 2 short. Capsule linear, flattened parallel with the partition, the two valves separating from the partition at maturity; seeds flat, broadly winged.*

1. B. capreolata L. CROSS VINE. Stem climbing high, a transverse section of the older stems showing a conspicuous cross formed by the 4 medullary rays; branches smooth. Leaves evergreen, petioled; leaflets 2, ovate, taper-pointed with a blunt apex, heart-shaped at the base, entire, stalked; upper leaflets transformed into branching tendrils. Flowers numerous, short-peduncled. Corolla 2 in. long, reddish-brown without, yellow within. Capsule 6 in. long, flat, the valves with a prominent central nerve; seeds broadly winged on the sides, short-winged on the ends. Common in woods S.*

92. OROBANCHACEÆ. BROOM RAPE FAMILY

Leafless brownish root parasites; rootstock often tuberous, naked or scaly; stem usually stout, solitary, scaly. Flowers spiked or racemed. Sepals 4–5, free from the ovary. Corolla hypogynous, not actinomorphic, the tube curved, the limb 2-lipped. Stamens 4 (2 long and 2 short), inserted on the corolla tube; anthers 2-celled, the cells spurred at the base. Ovary 1-celled, of 2 carpels; style simple; stigma 2-lobed; ovules many. Capsule 1-celled, 2-valved, few–many-seeded; seeds very small.

I. CONOPHOLIS Wallr.

Stems often clustered, stout, covered with scales which overlap, the uppermost ones each with an axillary flower, thus forming a spike. Calyx irregularly 4–5-cleft, split down the lower side. Corolla swollen below, decidedly 2-lipped, the upper lip arched. Stamens projecting.

1. **C. americana** Wallr. SQUAWROOT, CANCER ROOT. Stems 3–6 in. high, yellowish or yellowish-brown. Flowers numerous, inconspicuous. Corolla dirty white or pale brown. In oak woods; not very common.

II. OROBANCHE L. (THALESIA)

Brownish or whitish plants, with naked scapes borne on scaly, mostly underground, stems. Calyx regular, 5-cleft. Corolla 5-lobed, slightly irregular. Stamens not projecting from the corolla tube.

1. **O. uniflora** L. ONE-FLOWERED CANCER ROOT. Slightly covered with clammy down. Stems very short-branched, each with 1–3 1-flowered scapes 3–5 in. high. Calyx lobes lance-awl-shaped, half as long as the corolla. Corolla yellowish-white, veiny, purple-tinged; palate with 2 yellow bearded ridges. Damp woods.

2. **O. fasciculata** Nutt. Stem scaly, upright, 3–4 in. high above ground and generally longer than the numerous 1-flowered peduncles. Calyx lobes short, triangular. Parasitic on wild species of *Artemisia*, etc., in sandy and loamy soil N.W. and W.

93. ACANTHACEÆ. ACANTHUS FAMILY

Herbs or shrubs. Leaves opposite or whorled, without stipules. Flowers zygomorphic, usually with large bracts. Calyx of 4 or 5 unequal segments which considerably overlap each other. Corolla 4–5-parted and usually more or less 2-lipped. Stamens usually 2 long and 2 short, sometimes only 2. Ovary free from the calyx. Fruit usually a capsule. Seeds not winged. A large family, mostly tropical, with only a few insignificant wild species in the northern United States.

I. DIANTHERA L.

Perennial herbs; stem smooth. Leaves opposite, entire or toothed. Flowers axillary, solitary or clustered, zygomorphic. Calyx 5-parted. Corolla 2-lipped; upper lip erect, concave, entire or notched; the lower prominently veined, spreading, 3-lobed. Stamens 2, inserted in the throat of the corolla. Ovary 2-celled, 4-ovuled; style simple, acute. Capsule flattened, narrowed below into a little stalk.*

1. D. americana L. WATER WILLOW. Stem erect, slender, 2–3 ft. high. Leaves lanceolate to linear-lanceolate, taper-pointed at the apex, narrowed below to the sessile or short-petioled base. Flowers bracted, in short spikes, on peduncles as long as the leaves. Corolla pale blue or purple, the tube as long as the lips, lower lip wrinkled. Capsule about the length of the calyx. In water, S.*

II. RUELLIA L.

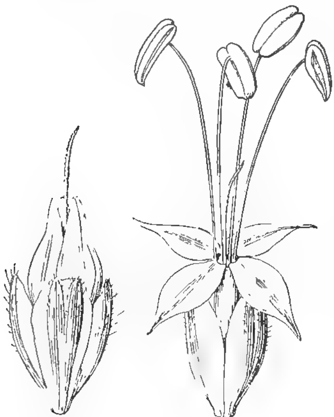
Perennial herbs; stems swollen at the joints and often between them, somewhat 4-angled. Leaves sessile or short-petioled, mostly entire. Flowers axillary, solitary or clustered, showy, white, blue, or purple. Calyx 2-bracted, 5-parted, the divisions linear and awl-shaped. Corolla tube slender, often much elongated, the limb spreading, nearly equally 5-lobed. Stamens 4 (2 long and 2 short), included or slightly projecting. Style slender. Capsule slender, narrowed below, 4–12-seeded.*

1. R. ciliosa Pursh. HAIRY RUELLIA. Stem erect, rather stout, often few-branched above, covered with white hairs, 4–30 in. high. Leaves oblong to ovate, acute or obtuse at the apex, narrowed and mostly sessile at the base, hairy-fringed. Flowers pale blue, solitary or 2–3 together. Calyx lobes bristle-shaped, half the length of the corolla tube. Tube of the corolla 2 in. long. Capsule shorter than the calyx, smooth, 8–12-seeded. A very variable species, the flowers often without a corolla. In dry woods and fields S.*

2. R. strepens L. SMOOTH RUELLIA. Stem erect, slender, usually simple, smooth or hairy, 1–3 ft. high. Leaves ovate to oblong, acute at the apex, narrowed below into a short petiole. Flowers solitary or in small clusters, sessile or short-peduncled. Calyx lobes shorter than the tube of the corolla, downy or fringed. Corolla blue, the tube 1½–2 in. long, the limb 1–1½ in. wide. Capsule usually longer than the calyx, smooth, 8–12-seeded. The later flowers often without a corolla. On rich, dry soil.*

94. PLANTAGINACEÆ. PLANTAIN FAMILY

Annual or perennial scape-bearing herbs. Leaves usually all basal, with parallel ribs. Flowers small, green, usually spiked, regular and bisexual (Fig. 28). Sepals 4, persistent. Corolla hypogynous, salver-shaped, thin and dry; lobes 4, spreading. Stamens 4, usually inserted on the corolla tube; filaments thread-like; anthers large and versatile. Ovary free, usually 2–4-celled; style thread-like. Fruit a 1–4-celled, 1 or more seeded membranous capsule, which splits open transversely, the top coming off like a lid.



A B

FIG. 28. Flowers of plantain (*Plantago lanceolata*), six times natural size

A, earlier stage, pistil mature, stamens not yet appearing outside the corolla; *B*, later stage, pistil withered, stamens mature

PLANTAGO L.

Characteristics of the genus as given above for the family.

1. P. major L. PLANTAIN. Perennial, from a very short rootstock. Leaves ovate to oval, strongly 5–9-ribbed, acute or obtuse at the apex, rounded at the base into a long, concave petiole, entire or toothed, smooth or slightly downy. Scape taller than the leaves, downy, spike densely flowered; bracts short, ovate. Flowers perfect. Stamens 4, projecting. Capsule ovoid, about twice the length of the calyx, 5–16-seeded; seeds angled and with a netted outer coat. Common in dooryards.*

2. P. Rugelii Decaisne. Leaves as in *P. major*, but smaller and thinner. Spikes less dense, usually drawn out to a slender point. Capsule 4–10-seeded; seeds oval, the outer coat not netted. In fields, woods, and waste ground.

3. P. lanceolata L. RIB GRASS. Biennial or perennial; soft-hairy or nearly smooth. Leaves numerous, lanceolate to elliptical, acute, long-petioled, strongly 3–5-ribbed, entire or toothed. Scapes much longer than the leaves, striate-angled, 1–2 ft. high; spike short and dense. Bracts and sepals ovate. Corolla smooth. Capsule longer than the calyx, 2-seeded. Naturalized from Europe; common in meadows.*

4. P. Purshii R. & S. Annual. White-woolly or silky. Scapes slender; leaves linear, usually 3-nerved; spikes dense, cylindrical, and very woolly; bracts stiff, as long as the flowers or slightly longer. Capsule 2–4-seeded, somewhat longer than the calyx. On dry prairies and plains W. and S.W.

5. P. aristata Michx. LARGE-BRACTED PLANTAIN. Annual. Leaves broadly linear, entire or sparingly and finely toothed, narrowed below into a margined petiole, smooth or silky-downy. Scape longer than the leaves, 6–10 in. high; spike dense. Bracts linear, ½–1 in. long. Stamens 4. Capsule 2-seeded, longer than the calyx. Common on dry soil.*

6. P. heterophylla Nutt. MANY-SEEDED PLANTAIN. Annual. Leaves linear, fleshy, entire or with a few spreading teeth, smooth or slightly downy. Scapes slender, 3–6 in. high; spike very slender, many-flowered, the lower flowers often scattered. Bracts ovate, longer than the sepals. Stamens 2. Capsule twice the length of the calyx, many-seeded. Common in cultivated ground, especially S.*

95. RUBIACEÆ. MADDER FAMILY

Herbs, shrubs, or trees. Leaves opposite and entire, with stipules between them, or appearing whorled since the stipules resemble the leaves. Flowers epigynous, always bisexual, frequently dimorphous (as in *Houstonia*, *Mitchella*, and *Bouvardia*). Limb of the calyx 3–6-toothed. Corolla regular, inserted on the calyx-tube, as many-lobed as the calyx. Stamens equal in number to the divisions of the corolla. Ovary 2 or more celled. A very large and important family, of which many of the noteworthy species, for instance the coffee shrub and the cinchona tree, are natives of warm or tropical climates.

I. GALIUM L.

Annual or perennial herbs; stems slender, 4-angled. Leaves appearing whorled. Flowers small, in axillary or terminal cymes or panicles, bisexual or rarely diœcious. Calyx tube short, the teeth minute or wanting. Corolla wheel-shaped, 3–4-lobed. Stamens 3–4, short. Ovary 2-celled; styles 2, short, united below. Fruit 2 united, sometimes fleshy, 1-seeded carpels, which do not split open.*

1. G. Aparine L. Goose Grass. Annual; stem weak, decumbent, sharply 4-angled and with backward-pointing prickly hairs, widely branched, 2–4 ft. long. Leaves 6–8 in a whorl, oblanceolate, prickly-hairy on the margins and midrib. Peduncles axillary, longer than the leaves, 1–3-flowered; flowers white. Fruiting pedicels erect; fruit dry, covered with hooked bristles. In waste places.*

2. G. circæzans Michx. Wild Licorice. Perennial; stems several, erect, smooth or downy, 12–18 in. high. Leaves 4 in a whorl, oval to ovate, obtuse at the apex, strongly 3-nerved, downy. Cymes long-peduncled, repeatedly branched. Flowers nearly sessile, greenish-purple; pedicels at length recurved. Fruit with hooked bristles. In dry, open woods S. Easily recognized by the sweet, licorice-like taste of the leaves.*

3. G. boreale L. Northern Bedstraw. Perennial; stem smooth, erect, 1–2 ft. high. Leaves in fours, linear-lanceolate, 3-nerved. Flowers bright white, in compact cymes, grouped in a dense panicle. Fruit usually with minute bristles. In rocky soil along banks of streams, especially N.

4. G. concinnum T. & G. Shining Bedstraw. Stems slender, smooth, shining, commonly much branched, 6–12 in. high, often with the angles minutely roughened. Leaves usually in sixes, linear or nearly so, often slightly cuspidate. Flowers small, white, in open cymes. Fruit small, smooth. Dry hills and woodlands.

5. G. asprellum Michx. Rough Bedstraw. Perennial; stem branching, weak, 3–5 ft. long, often reclining on bushes, with many hooked prickles directed backwards. Leaves usually in sixes, or on the branches in fours or fives, narrowly oval to lanceolate or oblanceolate, cuspidate, with midribs and margins almost prickly. Flowers white, in several–many-flowered cymes. Fruit smooth. In rich, moist soil.

6. G. triflorum Michx. Perennial; stems reclining or prostrate, angles rough-bristly. Leaves mostly in sixes, lance-oblong, mucronate. Flowers usually in threes, on slender peduncles. Woodlands, especially N.

7. G. hispidulum Michx. Bedstraw. Perennial, from yellow roots; stems diffusely branched, smooth or slightly roughened, downy at the joints, erect or decumbent, 1–2 ft. long. Leaves 4 in a whorl, narrowly oval, acute, rough on the margins and mid-vein. Peduncles 1–3-flowered; flowers white; pedicels becoming reflexed. Fruit a bluish-black, roughened berry. On dry, sandy soil.*

II. MITCHELLA L.

A pretty, trailing, evergreen herb. Leaves roundish-ovate, petioled. Flowers fragrant, white or pinkish, dimorphous, growing in pairs, joined by their ovaries. Calyx 4-toothed. Corolla funnel-shaped, with the lobes bearded within. Stamens 4, short. Style 1; stigmas 4, slender. Fruit double, composed of the united ovaries; really a drupe, containing 8 seed-like, bony nutlets, ripening into tasteless scarlet berries, which cling to the plant through the winter.

1. **M. repens** L. PARTRIDGE BERRY, SQUAW VINE, TWO-EYE BERRY. Common in dry woods, especially under evergreen coniferous trees.

III. BOUVARDIA Salisb.

Smooth perennials. Leaves lanceolate, thickish. Calyx 4-lobed, the divisions slender. Corolla with a long and narrow or rather trumpet-shaped tube, and spreading, 4-lobed limb. Anthers 4, inserted in the throat of the corolla, almost sessile. Stigmas 2, flat. Capsule globular, 2-celled, many-seeded. Flowers dimorphous.

1. **B. triphylla** Salisb. THREE-LEAVED BOUVARDIA. Somewhat shrubby. Leaves nearly smooth, ovate or oblong-ovate; the lower ones in threes, the upper ones sometimes in pairs. Corolla scarlet and slightly downy outside.

2. **B. leiantha** Benth. DOWNY-LEAVED BOUVARDIA. Leaves rather downy. Corolla deep scarlet, smooth outside.

Both species cultivated from Mexico; in greenhouses.

IV. HOUSTONIA L.

Annual, biennial, or perennial herbs; stems erect or diffuse. Leaves entire; stipules often only a line connecting the bases of opposite leaves. Flowers small, solitary or clustered, dimorphous, the stamens projecting and the style short in one form, while in the other the stamens are short and the style projecting. Calyx 4-toothed, persistent. Corolla wheel-shaped to funnelform, 4-lobed. Stamens 4. Ovary 2-celled; style slender; stigmas 2. Fruit a 2-celled, few–many-seeded capsule, opening at the apex, free from the calyx.*

1. **H. cœrulea** L. BLUETS, INNOCENCE, QUAKER LADIES, EYE-BRIGHT. Perennial, from very slender rootstocks; stems tufted, erect, smooth, forking, 3–6 in. high. Leaves sessile, often hairy-fringed, the lower spatulate, the upper lanceolate. Flowers solitary,

on slender axillary peduncles. Calyx small. Corolla salverform, blue or white, yellow in the throat, smooth. Capsule laterally compressed, 2-lobed, shorter than the calyx. Common on open ground.*

2. H. patens Ell. SMALL BLUETS. Annual; stem erect, branched at the base, forking above, smooth, 2–4 in. high. Lower leaves oval to ovate, petioled, the upper narrower and sessile. Flowers solitary, on slender, axillary peduncles, blue or white. Calyx small. Lobes of the corolla about as long as the tube. Stamens and style projecting or included. Capsule compressed, as long as the calyx. Common on dry, open ground.*

3. H. purpurea L. LARGE BLUETS. Perennial; stem stout, erect, simple or branched, smooth or downy, 4-angled, 6–12 in. high. Leaves ovate to ovate-lanceolate, sessile or short-petioled, 3–5-nerved, often hairy-fringed on the margins. Flowers in terminal cymes, purple to nearly white. Corolla funnelform, the tube longer than the limb, hairy within. Stamens and style projecting or included. Capsule compressed-globose, much shorter than the calyx. In dry, open woods.*

4. H. longifolia Gaertn. LONG-LEAVED BLUETS. Perennial; stem erect, branched, smooth, 4-angled, 8–12 in. high. Leaves sessile, the lower oblanceolate or spatulate, the upper linear, 1-nerved. Corymbs terminal, few-flowered. Corolla light purple to white, the lobes much shorter than the tube. Capsule compressed-globose, nearly as long as the calyx. In dry, open woods.*

96. CAPRIFOLIACEÆ. HONEYSUCKLE FAMILY

Mostly shrubs. Leaves opposite, without true stipules. Flowers epigynous, often zygomorphic. Corolla tubular or wheel-shaped. Stamens usually as many as the corolla lobes and inserted on the corolla tube. Fruit a berry, drupe, or capsule.

I. DIERVILLA Mill.

Low, upright shrubs. Leaves taper-pointed, serrate. Flowers in loose terminal or axillary clusters or cymes. Calyx with a limb of 5 linear divisions. Corolla funnel-shaped, almost regularly 5-lobed. Stamens 5. Ovary slender, 2-celled, ripening into a 2-valved, many-seeded pod.

1. D. Lonicera Mill. COMMON BUSH HONEYSUCKLE. Bushy, 1–4 ft. high. Leaves ovate or oblong-ovate, petioled. Peduncles 1–3-flowered. Pods tapering to a slender point. Rocks, especially N.

2. D. japonica DC. WEIGELA. A stout, branching shrub, 3–6 ft. high. Leaves broadly oval, acute at the apex, rounded at the base, coarsely serrate, rough above, downy beneath, short-petioled. Flowers spreading, funnelform, rose color, 1–1½ in. long. Calyx lobes deciduous. Corolla downy without; the lobes spreading. Capsule oblong or spindle-shaped. Seeds with netted wings. Introduced from Japan; common in cultivation.*

II. LONICERA L.

Shrubs or woody vines. Leaves simple, usually entire, those of a pair often appearing as if joined together at the base, so that the stem seems to rise through them. Calyx tube ovoid, 5-toothed. Corolla tubular to bell-shaped, often knobbed at the base or 2-lipped. Stamens 5. Ovary 2–3-celled, ovules several in each cell; style slender; stigma knobbed. Fruit a 1–3-celled, 1–few-seeded berry.*

A

More or less upright bushes, not climbing.

1. L. tatarica L. TARTARIAN HONEYSUCKLE. A branching shrub, 5–8 ft. high. Leaves oval or ovate, heart-shaped, shining. Flowers many, showy, rose-colored. Fruit consisting of 2 red berries; somewhat united below at maturity. Cultivated from Asia.

2. L. canadensis Marsh. EARLY FLY HONEYSUCKLE. A straggling bush, 3–5 ft. high. Leaves ovate or oval, slightly heart-shaped, thin, at first downy beneath. Flowers straw-yellow, on short, slender peduncles. Corolla lobes nearly equal; tube pouched at the base. Fruit 2 separate red berries.

B

Stems twining.

3. L. japonica Thunb. JAPAN HONEYSUCKLE. Stem twining high; young branches downy. Leaves ovate to oblong, entire, smooth above, pale and downy beneath, all short-petioled. Peduncles axillary, 2-bracted, 2-flowered. Flowers white or pink, fading to yellow, 2-lipped, the lips nearly as long as the downy tube. Stamens and style projecting. Fruit black. Common in cultivation; introduced from Japan.*

4. L. sempervirens L. CORAL HONEYSUCKLE, TRUMPET HONEYSUCKLE. Stem twining high. Leaves evergreen (in the South), oval to oblong, obtuse, entire, smooth above, pale and often downy beneath; the lower petioled, the upper pair nearly semi-orbicular and joined at the base. Flowering spikes terminal, bearing several whorls. Corolla about 2 in. long, slender, smooth; the limb short, nearly equally 5-lobed, scarlet without, bright yellow within. Stamens slightly projecting; fruit red. On low ground; often cultivated.*

5. L. Caprifolium L. EUROPEAN HONEYSUCKLE. A moderately high-climbing shrub. Leaves smooth and deciduous, several of the upper pairs united at their bases to form a flattish disk or somewhat cup-shaped leaf. Flowers in a single terminal whorl, very sweet-scented. Corolla whitish, red, or yellow, 2-lipped, with the lips recurved. Cultivated from Europe.

6. L. Sullivantii Gray. YELLOW HONEYSUCKLE. Stem somewhat twining. Leaves oval to obovate, obtuse, entire, green above, with a bloom beneath, the lower short-petioled, the upper sessile or joined at the base. Flowers in crowded, terminal whorls, bright yellow, fragrant. Corolla tube slender, 1–1½ in. long, bilabiate, 4-lobed, pubescent within. Stamens and style projecting. On river banks and hillsides; often cultivated.*

III. SYMPHORICARPOS Ludwig

Shrubs. Leaves short-petioled, deciduous. Flowers in axillary clusters. Calyx tube globose, 4–5-toothed. Corolla bell-shaped, 4–5-lobed, sometimes knobbed at the base, smooth or hairy within. Stamens 4–5. Ovary 4-celled; 2 of the cells with a single fertile ovule in each, the other cells with several abortive ovules; style slender; stigma knobbed or 2-lobed. Fruit a 4-celled, 2-seeded berry.*

1. S. racemosus Michx., var. **lævigatus.** SNOWBERRY. An ornamental shrub, 2–3 ft. high. Flowers in loose terminal racemes, which are often leafy. Corolla bell-shaped, much bearded inside, pinkish-white. Stamens and style not projecting. Berries rather large, snow-white, remaining long on the branches. Rocky banks, often cultivated.

IV. LINNÆA L.

A very small, slender, creeping evergreen shrub; branches inclined, ending in a slender, erect, 2-flowered peduncle. Leaves opposite, without stipules. Flowers nodding, on slender pedicels, with 2 bractlets. Calyx tube ovoid; limb 5-lobed. Corolla nearly bell-shaped, 5-lobed. Stamens 4, inserted near the base of the corolla; 2 of them longer than the other 2.

Ovary 3-celled; style thread-like; stigma knobbed; ovules many in 1 cell, solitary in the 2 others. Fruit nearly globose, 1-seeded.

1. L. borealis L. Twin Flower. A beautiful, delicate plant. Corolla pale pink, very fragrant. Moist woods, in moss and cold bogs N.

V. TRIOSTEUM L.

Coarse, hairy, perennial herbs. Leaves large, those of each pair somewhat joined at the base, so that the stem appears to rise through them. Calyx tube ovoid; divisions of the limb leaf-like, lance-linear, persistent. Corolla knobbed at the base, nearly equally 5-lobed. Ovary usually 3-celled, ripening into a drupe with 3 nutlets.

1. T. perfoliatum L. Tinker Weed, Wild Coffee, Feverwort, Horse Gentian. Stem unbranched, soft-hairy, 2–4 ft. high. Leaves spatulate-ovate, abruptly narrowed at the base, 4–7 in. long and 2–4 in. wide, bordered with a fringe of hairs. Flowers dark brownish-purple. Corolla about ½ in. long, sticky-downy. Fruit ellipsoidal, orange-colored when ripe. Common along fence rows and in rocky woods.

VI. VIBURNUM L.

Shrubs or small trees. Leaves simple, entire, dentate or lobed, with or without stipules. Flowers small, white, in terminal cymes; the outer flowers of the cyme sometimes greatly enlarged and sterile. Calyx tube very small, 5-toothed. Corolla wheel-shaped or bell-shaped, 5-lobed. Stamens 5, inserted in the tube of the corolla. Ovary 1–3-celled, 1–3-ovuled, but only 1 ovule maturing; style short, 3-lobed. Fruit a 1-seeded drupe, with soft pulp.*

A

Flowers around the margin of the cyme without stamens or pistils, large and showy.

1. V. alnifolium Marsh. Hobblebush, Witch Hobble. A shrub about 5 ft. high, with the branches reclining and often rooting and forming loops (whence the popular names). Leaves very large, roundish, abruptly taper-pointed, serrate, with a rusty down on the petioles and veinlets. Cymes very broad and showy. Fruit red, not eatable.

2. V. Opulus L., var. **americanum.** CRANBERRY TREE, HIGH-BUSH CRANBERRY. A handsome, upright shrub. Leaves 3–5-ribbed and 3-lobed. Fruit bright red, juicy, very acid, and used as a substitute for cranberries. Common N. The form known as "snowball," with all the flowers showy and sterile, is cultivated from Europe.

B

Flowers all small and bisexual.

3. V. acerifolium L. MAPLE-LEAVED ARROWWOOD. A slender shrub, 3–6 ft. high. Leaves broadly ovate to heart-shaped, palmately veined and 3-lobed, serrate or nearly entire, petioled, downy, becoming smooth above. Cymes peduncled, about 7-rayed, 2–3 in. wide; sterile flowers none. Fruit oval, black; stone flat, 2-ridged on the edges. In dry, open woods.*

4. V. dentatum L. ARROWWOOD. A shrub 8–15 ft. high. Leaves broadly ovate to oval, acute at the apex, rounded or heart-shaped at the base, coarsely dentate, smooth above, hairy in the axils of the veins beneath, short-petioled. Cymes long-peduncled, 7-rayed, 2–3 in. wide; sterile flowers none. Calyx smooth. Fruit globose, dark blue; stone compressed, grooved on one side. In rich, damp soil.*

5. V. nudum L. WITHE-ROD. A shrub 8–12 ft. high. Leaves ovate to lanceolate, entire or slightly toothed, acute at both ends, thick, smooth above, the veins prominent beneath; petiole short. Cymes short-peduncled, 5-rayed; sterile flowers none. Fruit ovoid, blue. Common in swamps.*

6. V. Lentago L. NANNYBERRY, SHEEPBERRY. A shrub or small tree, sometimes 30 ft. high. Leaves ovate, sharply serrate, taper-pointed, usually smooth on both sides. Flower clusters large compound cymes. Fruit oval, ½ in. or more long, bluish-black, with a bloom, eatable. In woods and on banks of streams.

7. V. prunifolium L. BLACK HAW. A small tree, 15–20 ft. high. Leaves oval to ovate, acute or obtuse at each end, finely and sharply serrate, smooth and shining above, often slightly downy beneath; petioles dilated and rusty-downy. Cymes sessile, large, 4–5-rayed; sterile flowers none. Fruit oval, bluish-black, eatable. In rich, moist woods.*

VII. SAMBUCUS L.

Shrubs with odd-pinnate leaves. Calyx limb minute or wanting. Flowers very many, small, white, in compound cymes. Corolla with a small, somewhat urn-shaped tube, and a flattish, spreading, 5-cleft limb. Stamens 5. Stigmas 3, sessile. Fruit a globular, pulpy drupe, 3-seeded, appearing like a berry.

1. **S. canadensis** L. COMMON ELDER. Stems 5–10 ft. high, with a thin cylinder of wood surrounding abundant white pith. Leaflets 5–11, oblong, taper-pointed, smooth. Cymes flat and often very large. Fruit purplish-black, insipid or almost nauseous, but somewhat used in cookery.

2. **S. racemosa** L. RED-BERRIED ELDER. More woody, with brown pith. Leaflets fewer, downy beneath, especially when young. Cymes panicled and somewhat pyramidal. Fruit scarlet.

97. VALERIANACEÆ. VALERIAN FAMILY

Herbs, rarely shrubs. Leaves opposite, without stipules. Flowers epigynous, small, usually not actinomorphic, in forking cymes. Corolla funnel-shaped, the base often with a sac or spur. Stamens 1–3 or 5, inserted at the base of the corolla tube; filaments slender, anthers versatile. Ovary cells 3; two of them not ovule-bearing, the third with a single ovule hanging from the top; style thread-like; stigma blunt or 2–3-lobed. Fruit small, not splitting open.

I. VALERIANA L.

Perennial, rarely annual, herbs. Basal leaves crowded; stem leaves opposite or whorled, entire or pinnately cut. Flowers in corymbed, headed, or panicled cymes. Limb of the calyx consisting of several plumy bristles. Lobes of the corolla 5 or rarely 3–4, unequal. Stamens 3. Stigma knobbed. Fruit flattened, ribbed, 1-celled, 1-seeded.

1. **V. edulis** Nutt. An upright, straight-stemmed plant, 1–4 ft. high. Leaves all thickish and closely fringed with short hairs; root leaves linear-spatulate or lanceolate-spatulate, entire; stem leaves pinnately parted, the 3–7 divisions long and narrow. Flowers almost diœcious in a long, interrupted panicle. Corolla whitish. Root long and stout, eaten by Indians. Low ground and wet prairies, especially N.W.

2. **V. officinalis** L. GARDEN VALERIAN. Plant smooth or hairy below, strong smelling. Rootstock short. Leaves all pinnate; basal leaves long-petioled, soon withering; stem leaves 2–5 in. long, sessile, the leaflets lanceolate, entire or serrate. Corolla pale pink. Rootstocks strong-scented, used in medicine. Cultivated from Europe.

II. VALERIANELLA Hill

Annual herbs; stem forking regularly. Leaves opposite, entire or dentate. Flowers in crowded, terminal, bracted cymes. Calyx limb toothed or wanting. Corolla white or purplish, funnelform, 5-lobed. Stamens 3. Style 3-lobed. Fruit 3-celled, 1-seeded.*

1. **V. Locusta** Betcke. LAMB LETTUCE. Stem erect, smooth, or downy at the nodes, many times forked, 9–12 in. high. Basal leaves tufted, spatulate to obovate, entire; the upper lanceolate, dentate, sessile. Cymes short-peduncled, bracts linear. Flowers pale blue. Fruit compressed, oblique. On rich soil in waste places. Sometimes cultivated for salad. Introduced from Europe.*

2. **V. radiata** Dufr. CORN SALAD. Stem erect, smooth above, downy below, 2–4 times forked, 8–12 in. high. Lower leaves spatulate, entire; the upper lanceolate, clasping at the base, dentate. Cymes compact; bracts lanceolate. Flowers white. Fruit ovoid, downy, furrowed. On damp soil.*

98. CUCURBITACEÆ. GOURD FAMILY

Somewhat succulent, tendril-bearing, prostrate or climbing, herbaceous plants. Leaves alternate, with stipules. Flowers epigynous, diœcious or monœcious, often sympetalous. Calyx limb (if present) 5-lobed. Corolla usually 5-lobed and with its tube more or less united with the calyx tube. Stamens perigynous or borne upon the corolla; the anthers usually joined in long, serpentine ridges. Ovary 3-celled; stigmas 2 or 3. Fruit generally a pepo (like the melon, squash, and pumpkin), but sometimes dry. Seeds commonly large and flat. A large family, mostly of tropical plants, many with eatable fruit, but some species poisonous.

I. CUCURBITA L.

Annual or perennial herbs; stem trailing or climbing, 2–20 ft. long. Leaves angular-lobed; tendrils branching. Flowers monœcious, solitary or in small clusters. Calyx 5-toothed, the limb deciduous. Corolla bell-shaped, 5-lobed. Staminate flowers with 3 stamens and no pistil; pistillate flowers with 1 pistil and 3 imperfect stamens. Style short; stigmas 3–5, each 2-lobed. Fruit 1-celled, with numerous seeds on the 3 parietal placentæ.*

1. **C. fœtidissima** HBK. Missouri Gourd. Stem stout, rough and hairy. Root very large, carrot-shaped. Leaves thick, triangular heart-shaped. Flowers 3–4 in. long. Fruit globose or somewhat obovoid, 2–3 in. in diameter. Dry soil W. and S.W.

2. **C. Melopepo** L. Summer Squash. Stem rough-hairy, angled, 2–5 ft. long. Leaves broadly heart-shaped, angularly 3–5-lobed, rough. Flowers yellow, short-peduncled. Fruit roundish, longitudinally compressed, the margin smooth, wavy, or tubercular. Common in cultivation.*

3. **C. verrucosa** L. Crookneck Squash. Stem rough-hairy, angled and striate, 5–10 ft. long. Leaves cordate, deeply 5-lobed, very rough, long-petioled. Flowers light yellow, long-peduncled. Fruit clavate, the base often slender and curved, smooth or tuberculate, very variable. Common in cultivation.*

II. CUCUMIS L.

Annual herbs; stems trailing, usually shorter and more slender than in the preceding genus; tendrils not forked. Leaves varying from entire or nearly so to deeply cut. Sterile flowers in clusters, fertile ones solitary in the leaf axils. Corolla of 5 acute petals, which are but little joined at the base. Stamens not evidently united. Style short; stigmas 3, each 2-lobed. Fruit rather long. Seeds not large, lance-oblong, not margined.

1. **C. sativus** L. Cucumber. Leaves somewhat lobed, the middle lobe largest. Fruit more or less covered when young with rather brittle, blackish prickles, which fall off as it ripens. Cultivated from S. Asia. [Other varieties of the genus *Cucumis* are the muskmelon, cantaloupe, and nutmeg melon. Other commonly cultivated genera are *Citrullus*, the watermelon, and *Lagenaria*, the bottle gourd. Two wild genera, *Echinocystis*, the wild cucumber, and *Sicyos*, the star cucumber, which blossom through the summer and autumn, are common in the northern states and the Middle West.]

99. CAMPANULACEÆ. Campanula Family

Herbs, with milky juice. Leaves alternate, without stipules. Flowers epigynous, actinomorphic, not clustered. Calyx 5-lobed. Corolla regular, bell-shaped, 5-lobed. Stamens 5, usually free from the corolla and not united. Style 1, usually hairy above; stigmas 2 or more. Fruit a capsule, 2 or more celled, many-seeded.

I. SPECULARIA Fabricius

Annual; stems slender, angled. Leaves entire or toothed. Flowers axillary, regular, solitary or in small clusters, sessile, bracted. Calyx tube slender, 3–5-parted. Corolla wheel-shaped, 5-lobed. Stamens with the filaments flattened and shorter than the anthers. Ovary 3-celled, many-ovuled; stigmas 3. Fruit a prismatic, 3-celled, many-seeded capsule.*

1. S. perfoliata A. DC. Specularia. Stem erect, simple or branched from the base, angles roughened, 10–20 in. high. Leaves ovate to lanceolate, acute at the apex, sessile, crenate or entire, the upper bract-like. Flowers solitary or in pairs. Corolla blue, often wanting. Capsule cylindrical, smaller above. In waste places.*

II. CAMPANULA L.

Annual, biennial, or perennial herbs. Flowers solitary, racemed or spiked, regular, blue or white. Calyx 5-lobed or parted. Corolla wheel-shaped to bell-shaped, 5-lobed. Stamens 5, free from the corolla, distinct; filaments dilated at the base. Ovary 3–5-celled, many-ovuled; style 3-parted. Capsule short, bearing the persistent calyx lobes at its apex, many-seeded, splitting open on the sides.*

1. C. americana L. Tall Bellflower. Annual or biennial. Stem erect, usually unbranched, 3–6 ft. high. Leaves varying from ovate to lanceolate, serrate, 2½–6 in. long. Spike 1–2 ft. long. Corolla wheel-shaped, light blue, about 1 in. in diameter. Moist, rich soil, especially in thickets.

2. C. rotundifolia L. Harebell. A slender, smooth, branching perennial, 5–12 in. high. Root leaves broadly ovate-heart-shaped, generally somewhat crenate, soon withering; stem leaves varying from linear to narrowly lanceolate, entire. Pedicels slender; flowers solitary or somewhat racemed, the buds erect but the fully opened flower drooping. Calyx teeth erect, awl-shaped. Corolla bell-shaped, ½–1 in. long, its lobes short and recurved. Rocky hillsides, especially N.

3. C. aparinoides Pursh. Marsh Bellflower. Stem angular, unbranched, slender, weak, and leaning on the grass among which it usually grows, the angles clothed with minute, backward-pointing prickles. Leaves lance-linear, nearly entire. Flowers terminal, about ⅓ in. long, white. Corolla bell-shaped. Wet meadows, in tall grass.

100. COMPOSITÆ. Composite Family

Flowers epigynous, in a dense head, on a common receptacle, surrounded by an involucre composed of many bracts (Fig. 29), with usually 5 stamens inserted on the corolla, the anthers united into a tube which surrounds the style.

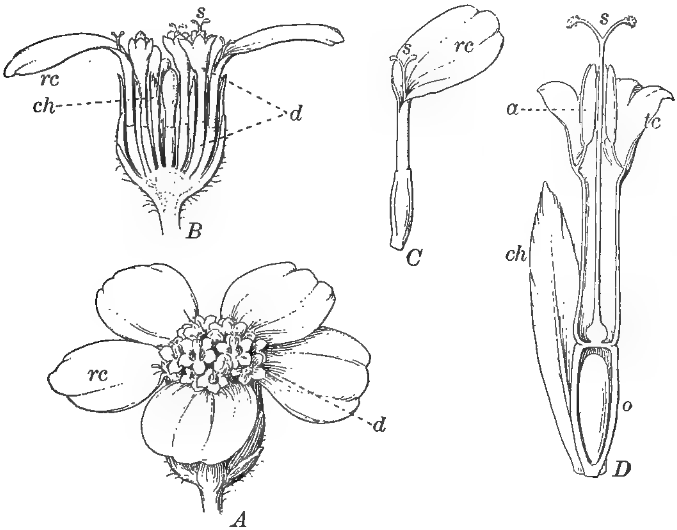


Fig. 29. Flower cluster and flowers of yarrow

A, flower cluster; *B*, section of flower cluster; *C*, a ray flower; *D*, a disk flower. *a*, anthers; *ch*, chaff of disk; *d*, disk flowers; *o*, ovary; *rc*, corollas of ray flowers; *s*, stigmas; *tc*, corolla of tubular flower. (*A*, *B*, *C*, 7 times natural size; *D*, 18 times natural size)

Calyx with its limb sometimes wanting; when present taking the form of scales, bristles, etc., known as *pappus* (Fig. 30). Corolla either strap-shaped (Fig. 29, *rc*) or tubular (Fig. 29, *tc*); in the former case often 5-toothed, in the latter usually 5-lobed. Style 2-cleft above. Fruit an akene, often provided with means of transportation. This is the largest family of flowering plants and among the most specialized for insect pollination. The genera of the northern United States are divided into two suborders: I. TUBULIFLORÆ, corolla of the bisexual flowers tubular and 5-lobed; II. LIGULIFLORÆ, corollas all strap-shaped and flowers all bisexual.

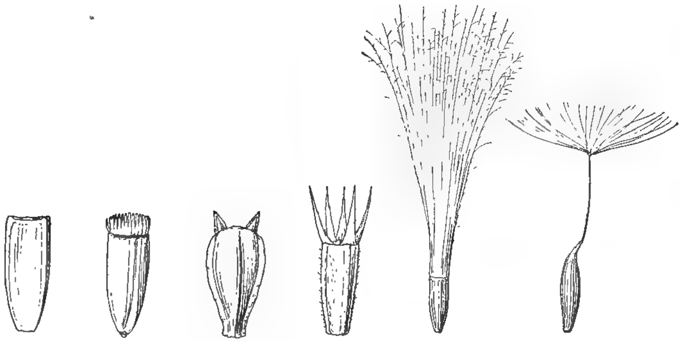


FIG. 30. Akenes with various types of pappus

A, *Rudbeckia*, pappus wanting; *B*, *Cichorium*, pappus a crown of fine scales; *C*, *Coreopsis*, pappus of 2 small scales; *D*, *Helenium*, pappus a crown of conspicuous scales; *E*, *Cirsium*, pappus a tuft of plumose hairs; *F*, *Lactuca*, pappus borne on a long beak

I. TUBULIFLORÆ [1]

Corollas some or all of them tubular.

Rays white, pink, or purplish.

Rays many; akenes flat; pappus wanting; low herbs. Bellis, I

Rays many; akenes cylindrical or winged, grooved; pappus wanting; tall herbs or shrubby. Chrysanthemum, X

Rays many; akenes flat; pappus of an outer row of minute scales and an inner row of delicate bristles. Erigeron, II

Rays many; akenes cylindrical or ribbed; pappus wanting; strong-scented, branching herbs. Anthemis, IX

Rays few. Achillea, VIII

[1] The characters in this key are not necessarily true of all species in the genera referred to, but only of those described below.

Rays yellow.
Disk purplish-brown. Rudbeckia, IV
Disk gray. Lepachys, V
Disk yellow.
Involucre of 2 rows of bracts, the outer rather leaf-like. Coreopsis, VI
Involucre of reflexed scales; pappus of 5–8 scales. Helenium, VII
Involucre of erect scales; pappus of abundant soft hairs. Senecio, XI

Rays none, but the marginal flowers sterile and their tubular corollas partly flattened like rays. Centaurea, XIII

Rays none, and marginal flowers like the others; scales of the involucre not prickly. Antennaria, III

Rays none and marginal flowers like the others; scales of the involucre overlapping in many rows, prickly-pointed. Cirsium, XII

II. LIGULIFLORÆ

Corollas all strap-shaped.

Corollas blue (rarely pinkish); akenes not beaked. Cichorium, XIV
Corollas blue; akenes beaked. Lactuca, XIX
Corollas yellow.
(*a*) Akenes truncate; pappus double, of chaff and bristles. Krigia, XV
(*b*) Akenes columnar; pappus of tawny, rough bristles; stem scape-like. Hieracium, XXII
(*c*) Akenes spindle-shaped, not beaked; pappus of plumed bristles. Leontodon, XVI

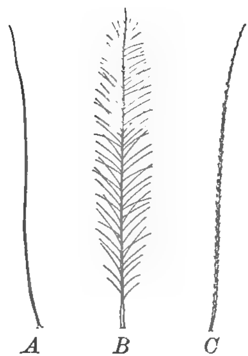


FIG. 31. Types of pappus hairs

A, smooth hair of dandelion; *B*, plumose hair of fall dandelion; *C*, rough or barbed hair of hawkweed. (7 times natural size) (*d*) Akenes ovoid to spindle-shaped, long-beaked, 4–5-ribbed; pappus white, soft, and abundant. Taraxacum, XVII

(*e*) Akenes nearly as in XVII; pappus tawny. Pyrrhopappus, XXI

(*f*) Akenes not flattened, with or without beak, 10-ribbed; pappus of abundant stiff, hair-like white bristles. Agoseris, XX

(*g*) Akenes flattened, beaked; pappus soft, white, the hairs soon falling off; leafy-stemmed herbs. Lactuca, XIX

(*h*) Akenes flattened, not beaked; pappus abundant, soft, white; leafy-stemmed, spiny-leaved herbs. Sonchus, XVIII

I. TUBULIFLORÆ

I. BELLIS L.

Small herbs. Leaves usually all basal, petioled. Heads solitary, disk yellow, ray flowers white or pink; involucre bell-shaped; bracts in 1 or 2 rows, green; receptacle conical. Ray flowers many, in a single row, pistillate; disk flowers tubular, bisexual, 4–5-toothed; forks of the style short, thick, tipped by roughened cones. Fruit flattened, obovate; pappus wanting.

1. **B. integrifolia** Michx. American Daisy. A branching annual or biennial herb, 4–12 in. high. Upper leaves lanceolate or oblong, the lower ones obovate-spatulate. Heads borne on slender peduncles; rays violet-purple. Prairies, especially S.W.

2. **B. perennis** L. English Daisy, Scotch Daisy. An apparently stemless perennial. Leaves obovate-spatulate, smooth or hairy. Heads $\frac{3}{4}$–1 in. in diameter, very pretty, the rays delicate. Cultivated from Europe.

II. ERIGERON L.

Herbs. Leaves usually sessile. Heads many-flowered, flat or nearly hemispherical, the rays numerous, narrow, pistillate. Scales of the involucre narrow and overlapping but little. Akenes flattish, crowned with a single row of hair-like bristles, or sometimes with shorter bristles or scales outside these. Disk yellow, rays white, pinkish, or purple.

B. Fl. species 5 (*Leptilon*).

1. **E. pulchellus** Michx. Robin's Plantain. Perennial; soft-hairy; stems sometimes throwing out offsets from the base; simple, erect, 1–2 ft. high. Basal leaves obovate-obtuse, somewhat serrate; stem leaves few, lance-oblong, acute, clasping. Heads rather large, 1–9, on long peduncles, with 50–60 long, rather broad, bluish-purple or reddish-purple rays. Thickets and moist banks.

2. **E. philadelphicus** L. Perennial; rather hairy; stems slender, about 2 ft. high. Basal leaves spatulate and toothed; stem leaves usually entire and strongly clasping, sometimes with a heart-shaped or eared base. Heads several, small, long-petioled; rays exceedingly numerous, thread-like, reddish-purple or flesh color. In damp soil.

3. **E. annuus** Pers. Common Fleabane. Annual or biennial. Stem grooved and stout, branching, 2–5 ft. high, with scattered hairs. Lowest leaves petioled, ovate, coarsely toothed; those higher up the stem successively narrower, sessile. Heads in a large, loose corymb; rays short, white or purplish. Fields and waste ground.

4. **E. ramosus** BSP. Daisy Fleabane. Annual or biennial. Considerably resembling the preceding species, but with entire leaves, smaller and less branched stem, smaller heads, and longer rays. Fields and pastures.

5. **E. canadensis** L. Horseweed, Butterweed, Colt's Tail. Annual; stem erect, 1–5 ft. high. Leaves linear, those of the stem entire. Heads very numerous and small, panicled; the white rays hardly longer than the pappus. A common and troublesome weed.

III. ANTENNARIA Gaertn.

Perennial woolly herbs. Leaves partly basal, the stem leaves alternate. Heads small, many-flowered, diœcious; the flowers all tubular. Involucre of thin, dry, white or colored bracts, imbricated in several series. Receptacle convex or flat, without chaff. Pistillate flowers with very slender tubular corollas and abundant pappus of hair-like, naked bristles, somewhat united at the base; pappus of the sterile flowers thickened and club-shaped at the tips. Akenes small, cylindrical or flattish.

1. **A. Parlinii** Fernald. Stolons ascending, leafy throughout; stems rather stout, at length 12–20 in. high, they and the stem leaves more or less downy with purplish glandular hairs. Basal leaves and those at the tips of the stolons at length smooth and bright green above; lower stem leaves abundant, oblong or narrower, obtuse or nearly so. Heads corymbed. Style at length crimson. Rich soil, frequently in open woods.

2. A. plantaginifolia Richards. COMMON EVERLASTING, PUSSY'S TOES. Stolons ascending, leafy throughout; stems slender, 4–20 in. high. Basal leaves and those at the tips of the stolons pale and very downy or covered with cobweb-like hairs above; stem leaves scattered, lanceolate, taper-pointed. Heads more or less closely corymbed. Styles crimson. In dry soil, very common.

3. A. solitaria Rydb. Stolons when well developed procumbent, leafy only at the tip; stems 2–8 in. high. Basal leaves obovate-spatulate, densely downy beneath, covered with cobweb-like hairs above, but becoming smoothish; stem leaves few, small, lying close to the stem. Heads solitary. Styles crimson. Rich wooded hillsides, central and south central states.

IV. RUDBECKIA L.

Perennial or biennial. Leaves alternate, entire or lobed. Heads radiate, long-peduncled, many-flowered; bracts imbricated in 2–3 series, spreading; receptacle convex or long-conical, with concave, chaffy scales. Ray flowers yellow, neutral; disk flowers purple to brown, bisexual. Akenes smooth, 4-angled, truncate. Pappus a few short teeth or wanting.*

1. R. hirta L. CONE FLOWER, BLACK-EYED SUSAN. Annual or biennial; stem erect, rough-hairy, simple or branched, 2–3 ft. high. Leaves lanceolate to oblong, thick, obscurely serrate, rough-hairy, 3-ribbed; the lower petioled, the upper sessile. Heads few, long-peduncled; bracts rough-hairy, spreading. Ray flowers 10–20, orange-yellow; disk flowers purplish-brown. Chaff acute, hairy at the apex. Pappus none. On dry, open ground.

V. LEPACHYS Raf. (RATIBIDA)

Perennial herbs. Leaves alternate, pinnately divided. Heads radiate, long-peduncled, many-flowered; bracts few, small, spreading. Receptacle columnar or slender, the chaff of concave truncate scales. Ray flowers yellow or with brown at the base, neutral; disk usually grayish.

1. L. pinnata T. & G. GRAY CONE FLOWER. Stem slender, branching, often 4 ft. or more high, gray with minute close-lying hairs. Leaves mostly large, pinnately 3–7-divided; the basal ones with long petioles, stem leaves sessile, the uppermost small. Disk oblong, gray or at length brown. Rays 4–10, light yellow, drooping, often 2 in. long. In dry prairie soil and borders of thickets.

2. **L. columnaris** T. & G. PRAIRIE CONE FLOWER. Stem rough-hairy, slender, usually branching from the base, 1–2 ft. high. Leaves pinnately divided into oblong to narrowly linear segments. Disk columnar, sometimes more than 1 in. long. Rays 4–10, drooping, yellow or partly or entirely brownish-purple, as long as or somewhat shorter than the disk. On dry prairies, especially W. and S.W.

VI. COREOPSIS L.

Annual or perennial herbs. Leaves opposite or the upper alternate, entire or pinnately divided. Heads radiate, solitary or corymbed, many-flowered; bracts in 2 rows of about 8 each, the inner membranaceous and appressed, the outer narrower and spreading; receptacle chaffy. Ray flowers neutral; disk flowers tubular, bisexual. Akenes compressed, oval to oblong, often winged. Pappus of 2 scales or bristles, or wanting.*

1. **C. tinctoria** Nutt. GARDEN COREOPSIS. Annual; stem erect, smooth, branched, 2–3 ft. high. Leaves 2–3 times pinnately divided, the divisions linear; lower leaves petioled, the upper often sessile and entire. Heads 1–1½ in. wide, on slender peduncles; inner bracts brown with scarious margins, outer bracts very short. Ray flowers about 8, yellow with a brown base, 3-lobed at the apex. Akenes linear. Pappus minute or none. Common in gardens.*

2. **C. lanceolata** L. TICKSEED. Perennial; stem slender, erect or ascending, smooth or slightly downy below, simple, 9–15 in. high. Leaves opposite, the lower spatulate to elliptical, sometimes lobed, on long, hairy-fringed petioles; the upper lanceolate, sessile. Heads few, on long peduncles; bracts ovate-lanceolate, the outer narrower. Ray flowers 6–10; rays 3–5-lobed, bright yellow. Akenes oval, broadly winged, warty. Pappus of 2 teeth. On rich, dry soil, S. and E.*

3. **C. grandiflora** Hogg. LARGE-FLOWERED TICKSEED. Usually perennial; stem smooth, commonly branched above, 1–3 ft. high. Most of the leaves once or twice pinnately parted, the lower sometimes entire, on slender petioles; segments of most of the stem leaves linear or thread-like. Heads usually several, 1¼–2 in. in diameter, on long peduncles; outer bracts lanceolate, narrower and shorter than the inner ones. Rays 6–10, yellow. Akenes oblong, with broad wings when ripe. In moist soil, especially S.W.

4. **C. auriculata** L. RUNNING TICKSEED. Perennial; stem ascending or decumbent, weak, smooth, nearly simple, 6–15 in. long. Leaves ovate to oval, entire or with 2–4 small and rounded lobes at the base, downy, long petioled. Heads 1–1½ in. wide, few or single; outer bracts narrower than the inner. Rays 6–10, mostly 4-toothed

at the apex; chaff as long as the flowers. Akenes oblong, the wings narrow and thickened; pappus of 2 minute teeth. In rich woods.*

5. C. palmata Nutt. Stiff Tickseed. Perennial; stem stiff, smooth, little or not at all branched, very leafy, 1–3 ft. high. Leaves 3-cleft, broadly wedge-shaped, stiff; the lobes linear-oblong, middle one often 3-lobed. Heads on short peduncles, few or solitary, 1¼–2 in. in diameter; bracts of the outer series narrower than the inner ones, slightly shorter. Rays 6–10, bright yellow, broad, usually 3-toothed. Akenes oblong, with narrow wings. Dry prairies and thickets W.

6. C. verticillata L. Perennial; stem smooth, stiff, slender, branching freely, leafy, 1–2 ft. high. Leaves divided into 3 sessile leaflets, the latter once or twice pinnately parted into narrowly linear or thread-like divisions. Heads 1¼–1½ in. in diameter; outer bracts much narrower than the inner ones. Rays 6–10, yellow. Akenes oblong, with narrow wings. In dry or moist soil, sometimes cultivated.

VII. HELENIUM L.

Annual or perennial. Leaves alternate, forming wings on the stem. Heads radiate, peduncled, many-flowered; bracts in 2 series, the outer linear and spreading, the inner few and scale-like; receptacle naked, convex or oblong. Ray flowers pistillate and fertile, or neutral, the rays wedge-shaped, 3–5-lobed; disk flowers bisexual, tubular, 4–5-lobed. Akenes top-shaped, hairy, ribbed; pappus of 4–5 entire, toothed or awned scales.*

1. H. nudiflorum Nutt. Sneezeweed. Perennial; stem slender, erect, downy, branched above, 1–2 ft. high. Leaves lanceolate, entire or slightly toothed, the lower petioled, the upper sessile. Heads numerous. Ray flowers 10–15, neutral, yellow or yellow and brown; disk flowers purple. Akenes hairy on the ribs; pappus of ovate, minutely toothed, awned scales. Common on river banks S.*

VIII. ACHILLEA L.

Perennial. Leaves alternate, pinnately divided. Heads with ray flowers in a terminal corymb; involucral bracts imbricated in several series, the outer shorter; receptacle chaffy. Ray flowers white or pink, pistillate and fertile; disk flowers bisexual, tubular, 5-lobed. Akenes oblong, compressed, slightly margined; pappus none.*

1. A. Millefolium L. Yarrow. Stems often clustered, erect from a creeping rootstock, simple, downy or woolly, 1–2 ft. high. Leaves lanceolate or oblong, the segments finely cut and divided, smooth or downy, the lower petioled, the upper sessile. Heads small, numerous, in flat-topped corymbs; bracts downy. Ray flowers 4–5, white or pink, rays 3-lobed at the apex. Common in old fields.*

IX. ANTHEMIS L.

Aromatic or ill-scented herbs. Leaves finely pinnately divided. Heads many-flowered, with ray flowers. Rays pistillate or neutral. Involucre of many small, dry, close-pressed scales. Akenes nearly cylindrical, generally ribbed, barely crowned or naked at the summit.

1. A. Cotula L. MAYWEED, DOG FENNEL. Leaves irregularly cut into very many narrow segments. Heads small, produced all summer. Disk yellow. Rays rather short, white, neutral. A low, offensive-smelling annual weed, by roadsides and in barnyards.

2. A. arvensis L. FIELD CHAMOMILE. Annual or biennial. Resembling *A. Cotula*, but without offensive smell. Leaves less finely once or twice pinnately parted. In fields and waste ground. Naturalized from Europe.

X. CHRYSANTHEMUM L.

Perennials, with toothed, pinnately cut or divided leaves. Heads nearly as in *Anthemis*, except that the ray flowers are pistillate.

1. C. Leucanthemum L. OXEYE DAISY, WHITEWEED, BULL'S-EYE, SHERIFF PINK. Stem erect, unbranched or nearly so, 1–2 ft. high. Basal leaves oblong-spatulate, petioled, deeply and irregularly toothed; stem leaves sessile and clasping, toothed and cut, the uppermost ones shading off into bracts. Heads terminal and solitary, large and showy, with a yellow disk and many white rays. A troublesome but handsome perennial weed. Naturalized from Europe, chiefly E.

2. C. frutescens L. MARGUERITE. Erect, branching, perennial, woody below, smooth, and with a pale bloom. Divisions of the leaves linear, with the uppermost leaves often merely 3-cleft bracts. Heads long-peduncled, showy, with a yellow disk and large, spreading white rays. Cultivated in greenhouses. From the Canary Islands.

XI. SENECIO L.

Annual or perennial; stems often hollow. Leaves alternate, entire or pinnately divided. Heads with or without rays, in terminal corymbs; bracts mostly in a single row, often with a few shorter ones at the base; receptacle naked or pitted. Ray flowers yellow or orange, pistillate and fertile when present; disk flowers tubular, bisexual. Akenes cylindrical or compressed, not beaked or winged, 5–10-ribbed, downy; pappus of numerous slender white hairs.*

1. S. glabellus Poir. BUTTERWEED. Annual; stem erect, ridged, hollow, often woolly when young and becoming smooth with age, branched above, 1–3 ft. high. Leaves lyrate-pinnatifid, thin, the lower petioled, the upper sessile. Heads radiate in a terminal corymb; bracts linear, acute. Ray flowers about 12, yellow. Akenes slightly rough-hairy on the angles; pappus rough, longer than the involucre. Common on low ground.*

2. S. aureus L. GOLDEN RAGWEED. Perennial; stems often tufted, erect, slender, woolly when young, branched above, 18–30 in. high. Lower leaves broadly ovate, obtuse at the apex, heart-shaped at the base, crenate, long-petioled; stem leaves lanceolate and often pinnatifid, the upper small and sessile. Heads radiate, corymbed, on slender peduncles. Ray flowers 8–12, bright yellow. Akenes smooth. In wet soil; very variable.*

3. S. tomentosus Michx. WOOLLY RAGWEED. Perennial; woolly throughout; stem stout, erect, mostly simple, 2–3 ft. high. Lower leaves ovate to oblong, crenate or entire, obtuse, long-petioled; stem leaves few, elliptical to oblanceolate, serrate or toothed, acute, sessile. Heads radiate, $\frac{3}{4}$ in. wide, on slender peduncles; bracts narrow, becoming smooth. Ray flowers 12–15, yellow. Akenes hairy. In damp soil.*

XII. CIRSIUM Hill. (CARDUUS)

Biennial or perennial; stem erect, simple or branched. Leaves alternate, prickly, often forming wings on the stem. Heads discoid, terminal and solitary or corymbed, many-flowered; bracts overlapping in many series, the outer shorter, usually spine-pointed; receptacle bristly. Corollas purplish or nearly white, the tube slender, deeply 5-cleft. Akenes oblong, 4-angled, smooth or ribbed; pappus of numerous simple or plumose bristles. [Most of our commoner species blossom in the late summer and autumn.]*

1. C. spinosissimum Scop. YELLOW THISTLE. Biennial or perennial; stem erect, stout, woolly when young, becoming smooth, often purple, branched, 1–3 ft. high. Leaves pinnately cut, with very spiny teeth, mostly sessile and clasping, smooth and green on both sides. Heads large, surrounded by a whorl of linear-oblong, comb-like leaves; involucral bracts linear, ciliate, not spine-tipped. Flowers purple or yellowish. On sandy soil E. and S.*

2. C. virginianum Michx. EARLY WOOD THISTLE. Stem woolly, slender, little or not at all branched, 1–3 ft. high. Leaves lanceolate, green above, covered beneath with dense white wool, the margins beset with prickly bristles, entire or sinuate-lobed, the lower ones sometimes pinnately cut into triangular-lanceolate lobes. Heads small, purple, on long leafless peduncles; outer scales of the involucre merely bristle-pointed. In dry woods and thickets.

XIII. CENTAUREA L.

Herbs. Leaves entire or cut, often spiny-toothed. Heads single; involucre ovoid or globose; bracts closely overlapping, often fringed, dry and membranaceous. Corollas all tubular, oblique or 2-lipped, inflated above; the outer ones usually larger and neutral, the inner flowers bisexual; lobes 5, slender. Akenes flattened; pappus hairs short, slender, rough.

1. Cyanus L. BACHELOR'S BUTTON. Stem erect, slender, grooved, 1–2 ft. high, somewhat branched. Leaves acute, sessile, narrow, entire or few-lobed. Peduncles covered with cottony wool. Heads $\frac{1}{2}$–1 in. in diameter, cobwebby. Ray-like flowers few, large, bright blue or pink; those of the disk smaller. Cultivated from Europe and escaped from gardens.

2. C. americana Nutt. PRAIRIE STAR THISTLE. Annual; stem stout, little or not at all branched, 2–6 ft. high. Leaves entire or minutely toothed, the basal and lower ones spatulate or oblong, petioled, the upper narrower, sessile and mucronate. Heads solitary at the summit of the stem or tips of the branches; involucre nearly hemispherical, the bracts ovate or lanceolate, with comb-like appendages. Flowers pink or purple, the marginal ones ray-like. In dry plains, especially S.W.

II. LIGULIFLORÆ

XIV. CICHORIUM L.

Perennial herbs with spreading branches; juice milky. Leaves radical and alternate, toothed or pinnately cut. Heads axillary; involucre cylindrical; bracts in 2 rows, the inner row erect, united at the base, the outer shorter; receptacle flattish. Corollas blue, pale pink, or yellow. Upper part of the style and its slender arms hairy. Akenes crowded on the hardened receptacle, firmly covered by the stiff involucre, obovoid or top-shaped, not beaked; pappus 1 or 2 rows of short scales.

1. C. Intybus L. CHICORY, BLUE DANDELION, BLUE SAILORS. Root very long, stout, and fleshy; stem 1–3 ft. high, angled and grooved; branches straight and stiff. Basal leaves and lower stem leaves runcinate; upper stem leaves oblong or lanceolate, clasping, those of the branches reduced to bracts. Flowers very showy, usually bright blue, rarely pinkish-white. Introduced from Europe; a troublesome weed in grass lands and common in waste places, particularly in New England.

XV. KRIGIA Schreber. (ADOPOGON)

Small, annual or perennial herbs. Leaves mostly basal, toothed or lyrate. Heads several–many-flowered; scales of the involucre about 2-rowed, thin. Akenes short, truncate; pappus in 2 rows, the outer one of thin, blunt, chaffy scales, the inner one of slender bristles. Corollas yellow.

1. K. virginica Willd. Annual; scapes usually 2–5 from one root, slender. Leaves mostly lyrate, smooth and with a bloom, the earlier ones rounded or spatulate. Scales of the involucre linear-lanceolate, nearly equal, spreading. Akenes top-shaped, reddish-brown, crowned with 5 wedge-obovate scales and 5 rough white bristles.

2. K. Dandelion Nutt. Perennial, from slender tuber-bearing roots; scapes leafless, 6–18 in. high. Leaves entire or nearly so, varying from spatulate-oblong to linear-lanceolate. Akenes more slender than in No. 1; pappus consisting of 10–15 small, oblong, chaffy scales, and 15–20 bristles. In moist ground, especially S.

3. K. amplexicaulis Nutt. Stem 12–18 in. high, often 2–3 from the same root, mostly 2-forked or 3-forked at the summit. Basal leaves 3–6 in. long, lanceolate, entire, toothed or rarely pinnately cut, clasping at the base; stem leaves 1–3. Akenes and pappus about as in No. 2. Moist banks.

XVI. LEONTODON L.

Perennial, scape-bearing herbs; juice milky. Leaves all basal, toothed or pinnatifid, often runcinate. Heads on simple or branched scapes, yellow; bracts of the involucre many, in several rows, the anther smaller; receptacle flat, naked. Arms of the style linear, obtuse, hairy. Akenes cylindrical, grooved, transversely wrinkled; beak short; pappus hairs stiff, in 1 or 2 rows.

1. L. autumnalis L. Scape usually branching, 5–15 in. high, bracted; peduncles enlarged above. Rootstock truncate. Heads 1½–1 in. or more in diameter; involucre top-shaped or bell-shaped. Pappus of a single row of tawny hairs. Fields and roadsides, especially N.E. Naturalized from Europe.

XVII. TARAXACUM Haller

Stemless perennial or biennial herbs. Leaves in a flattish tuft, pinnately cut or runcinate. Head many-flowered, large, solitary, yellow, borne on a hollow scape, which is short at first but lengthens after flowering. Involucre composed of a single row of long, erect inner scales, and a set of much shorter ones outside and at the base of the former ones. Akenes cylindrical or spindle-shaped, with 4–5 rough ribs, the apex tapering into a bristle-like beak which bears a short, broadly conical tuft of soft white hairs.

1. T. officinale Weber. Dandelion. Outer involucre reflexed; inner involucre closing over the head, after the flowers are withered, and remaining shut for some days, then opening and allowing the akenes to form a globular head. Root stout, bitter, medicinal. Young leaves eaten as a pot-herb ("greens") in spring — the plant often cultivated for the leaves by market-gardeners.

XVIII. SONCHUS L.

Annual or perennial. Leaves mostly toothed or pinnately cut, prickly margined. Heads in corymbs or panicles; bracts in several series, the outer shorter; receptacle naked. Flowers yellow, rays truncate, 5-toothed at the apex. Akenes oval to oblong, compressed, ribbed, truncate at the apex; pappus of numerous soft white hairs.*

1. S. oleraceus L. Sow Thistle. Annual; stem erect, branched, smooth, 2–6 ft. high. Leaves spiny-toothed, the lower long-petioled, very irregularly cut or pinnatifid, the upper clasping by an eared base. Involucre downy when young. Akenes channeled and transversely wrinkled. In waste places on very rich soil.*

2. S. asper Vill. Spiny Sow Thistle. Annual; stem erect, smooth, branched but little, 2–6 ft. high. Leaves undivided, spatulate to oblanceolate, fringed with spiny teeth; the lower narrowed into a petiole, the upper clasping by an eared base, the ears rounded.

Heads numerous; involucre glabrous. Akenes flattened, margined, 3-nerved on each side, smooth. In waste places.*

XIX. LACTUCA L.

Annual, biennial, or perennial; stems leafy. Leaves entire to pinnately cut. Heads panicled; involucre cylindrical; bracts unequal, overlapping in 2 or more rows, the outer shorter; receptacle naked. Flowers blue, yellow, or white; rays truncate, 5-toothed at the apex. Akenes compressed, ribbed, the apex contracted into a slender beak, which is enlarged into a disk bearing the soft, hairy, white or tawny pappus.*

1. **L. canadensis** L. WILD LETTUCE. Biennial; stem erect, smooth, hollow, branched above, 3–10 ft. high. Leaves lanceolate to spatulate, pale beneath, the lower petioled and pinnately cut, the upper sessile, clasping, and nearly entire. Heads numerous, about 20-flowered; flowers yellow. Akenes oval, flat, 1-ribbed on each side, minutely roughened, about as long as the beak; pappus white. In waste places.*

2. **L. acuminata** Gray. BLUE LETTUCE. Stem very leafy, smooth, paniculately branched above, 3–6 ft. high. Leaves ovate to lanceolate, taper-pointed, often hairy beneath; the lower on winged petioles and often sinuate-lobed, the upper sessile. Heads racemed, on divergent and bracted peduncles; flowers blue. Akenes slightly compressed, beak very short; pappus white. In waste places.*

XX. AGOSERIS Raf.

Herbs, usually appearing stemless. Basal leaves tufted, usually sessile. Head solitary, large, yellow or rarely purple, on a naked or bracted scape; bracts of the involucre overlapping in 2 or 3 rows; receptacle flat, naked or pitted. Akenes smooth, 10-ribbed, with or without a beak; pappus of abundant slender white bristles.

B. Fl. species 1 (*Nothocalais*).

1. **A. cuspidata** Steud. Scape 1 ft. or more high. Leaves lanceolate, taper-pointed, woolly-margined. Involucral scales lanceolate, sharp-pointed. Akenes beakless. Prairies and plains W.

2. **A. glauca** Steud. Scape stout, 1–2 ft. high. Leaves varying from linear to oblong, entire, dentate or pinnately cut. Heads 1–2 in. in diameter. Akenes beaked. Plains W.

XXI. PYRRHOPAPPUS DC. (SITILIAS)

Annual or biennial; stem erect, leafy below, nearly naked above, smooth. Leaves oblong, toothed or pinnatifid. Heads large, long-peduncled; involucre cylindrical or spreading, the inner row of bracts erect, united at the base, the outer rows shorter and spreading; receptacle naked. Flowers yellow; rays truncate, 5-toothed at the apex. Akenes oblong, 5-ribbed, narrowed above into a long and slender beak; pappus soft, tawny, with a short, soft-hairy ring at the base.*

1. **P. carolinianus** DC. FALSE DANDELION. Annual or biennial; stem glabrous, furrowed, branched above, 2–3 ft. high. Lower leaves lanceolate to oblong, entire, toothed or pinnatifid, narrowed into a margined petiole; the upper sessile, bract-like, entire. Heads few, long-peduncled; peduncles and involucre sometimes finely downy; inner bracts calloused at the apex, the outer awl-shaped and spreading. Akenes much shorter than the thread-like beak. Common in fields.*

XXII. HIERACIUM L.

Perennial herbs, often covered with glandular or star-shaped hairs; juice milky. Leaves alternate. Heads solitary, or in corymbs or panicles; bracts of the involucre many, overlapping, unequal; receptacle flattish, naked, pitted. Corollas yellow, rarely orange. Arms of the style slender and upper part of the style hairy; akenes angled or grooved, not beaked. Pappus hairs in a single row, simple, stiff, tawny or brownish, brittle. [Most of our commoner species bloom in the late summer or autumn.]

1. **H. aurantiacum** L. ORANGE HIERACIUM, DEVIL'S PAINT BRUSH. Stem leafless or occasionally with 1 or 2 small sessile leaves, clothed with long hairs. Basal leaves oblanceolate, hairy, 2½–6 in. long. Scapes 8–24 in. high. Heads corymbed, about ¾ in. in diameter, orange-red. A common weed, naturalized from Europe.

2. **H. venosum** L. RATTLESNAKE WEED. Stem scape-like, usually leafless or nearly so, smooth, 1–2 ft. high. Basal leaves 2–5 in. long, obovate or ovate-oblong, generally purple-veined. Heads rather large, yellow, in a loose panicled corymb. Dry hills and roadsides, and in pine woods E.

GLOSSARY

OF TECHNICAL TERMS USED MAINLY IN THE FLORA

Abortive, imperfectly developed.

Actinomorphic, having radial symmetry.

Adventive, partially naturalized.

Appressed, lying flat throughout its length, used of such parts as bracts.

Awl-shaped, narrow and tapering to a point.

Awned, having a bristle-like appendage.

Awnless, not awned.

Bisexual, having both stamens and pistils in the same flower.

Caducous, falling away very early.

Capitate: (1) having a round head like the stigma of a primrose; (2) growing in heads.

Carpellary, relating to a carpel.

Chaff, small membranous scales, such as are found on disks of *Compositæ*.

Ciliate, having the margins fringed with hairs or bristles.

Clasping, partly surrounding the stem; said of the bases of leaves.

Claw, the narrowed base of a petal.

Cleft, cut halfway down.

Coated (bulbs), those with scales which completely cover them, as in the onion.

Cone, the fruit of pines, etc., with ovule-bearing scales.

Connate, united; said of opposite leaves which appear as if grown together at their bases.

Convolute, rolled up lengthwise.

Convolute

Cordate, heart-shaped.

Corm, a bulb-like, fleshy stem or base of a stem.

Crown, an inner appendage to a petal or to the throat of the corolla.

Deciduous, falling as petals do after blossoming, or as leaves of most trees except evergreens do.

Declined, directed obliquely.

Decumbent, reclining, but with the summit somewhat erect.

Dehiscent, splitting into definite parts.

Diffuse, spreading widely or loosely.

Dimorphous, occurring under two forms, as in flowers with long and with short styles.

Disk: (1) an outgrowth of the receptacle within the calyx or within the corolla and stamens; (2) the central part of the head (all but the rays) in *Compositæ*.

Dissected, deeply divided or cut into many segments.

Drupe, a stone fruit such as a peach or a plum.

Equitant, leaves astride of those within them, thus appearing in a cross section like the diagram, <<<.

Even-pinnate, abruptly pinnate, i.e. with no leaflet at the end.

Fascicle, a close cluster or bundle of flowers, leaves, stems, or roots.

Fertile, capable of producing fruit; fertile flowers, those which have pistils.

Filiform, thread-shaped.

Fleshy, succulent, thick and full of sap.

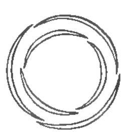
Funiculus, the little stalk which connects a seed or ovule with the placenta.

Gland: (1) a structure which secretes something, as the knobs on the hairs of sundew; (2) any knob or swelling.

Glume, one of the two sterile, chaffy bracts at the base of a grass spikelet.

Herbaceous, with no stem aboveground which lives through the winter, not woody or shrubby.

Imbricate, overlapping, as the segments of some perianths in the bud. At least one segment must be wholly outside and one wholly inside.



Imbricate

Indefinite, too many to be easily counted.

Indehiscent, not splitting open regularly.

Introduced, term applied to plants purposely brought into a region by man.

Involucrate, provided with an involucre.

Keel, the two anterior and united petals of a papilionaceous corolla.

Key, a winged fruit like that of the ash or maple.

Limb, the border or spreading part of a gamopetalous calyx or corolla.

Lobed, having divisions, especially rounded ones.

Lodicule, one of the very minute scales immediately beneath each flower in a grass spikelet.

Naturalized, term applied to plants not natives of a region but thoroughly established there in a wild condition.

Nerved, having simple or unbranched veins or slender ribs.

Ob- (in composition), signifies inversely; as, obcordate, inversely heart-shaped.

Odd-pinnate, pinnate with a single leaflet at the end of the midrib.

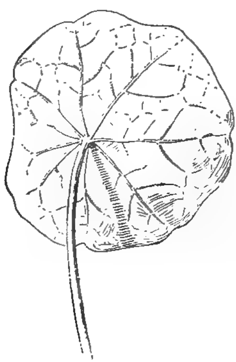
Palate, a projection in the throat of a corolla.

Palet, one of the bracts which subtend the flowers in a grass spikelet.

Papilionaceous, butterfly-shaped, like the corolla of the sweet pea.

Papillose, covered with papillæ or minute projections, like the human tongue.

Pappus, tufts of hair or other objects, representing the limb of the calyx in *Compositæ* (Fig. 30).



Peltate

Peltate, shield-shaped, that is with the stalk attached somewhere within the circumference of the leaf or other organ.

Perfoliate, with the stem apparently growing up through a leaf, as in some honeysuckles.

Persistent, not deciduous.

Pinnatifid, pinnately cleft.

Pistillate, having pistils but not stamens.

Plumose, feathered, as the pappus of thistles (Fig. 31).

Pubescent, clothed with soft hair, downy.

Punctate, marked with dots, depressions, or translucent glands.

Reflexed, bent or turned abruptly downward or backward.

Root parasite, a plant parasitic on the roots of another.

Sagittate, arrow-shaped.

Scape, a leafless flower stalk arising from the ground, as in the dandelion and cyclamen.

Scarious, thin, dry, and membranous, not green.

Sessile, without a stalk.

Simple (stem), unbranched.

Spadix, a spike with a fleshy axis, like that of the Indian turnip or the "calla."

Spathe, a large bract which incloses a flower cluster, often a spadix.

Staminate, having stamens only.

Standard, the posterior petal of a papilionaceous corolla.

Sterile: (1) barren, as a flower without a pistil or an antherless stamen; (2) staminate or male, said of flowers.

Striate, marked with fine longitudinal parallel lines.

Sub- (in composition), somewhat, as subglobose.

Subtend, to extend beneath as a bract in the axil of which a flower is borne.

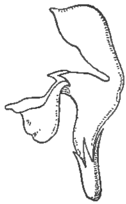
Succulent, fleshy or juicy.

Three-ranked, with three vertical rows on a stem or axis.

Throat, the top of the tubular part of a sympetalous corolla.

Truncate, appearing as if cut squarely off, as the leaves of the tulip tree.

Tubercled, covered with warty growths.

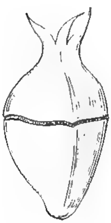


Two-lipped

Tubercular, having tubercles, or like a tubercle.

Two-lipped, having the limb of the calyx or corolla divided into two lip-like portions, as in the *Labiatæ*.

Two-ranked, with two vertical rows on a stem or axis.



Utricle

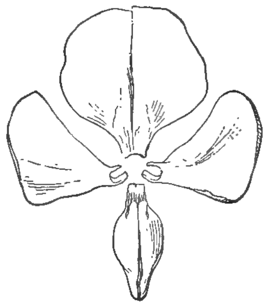
Unisexual, having in each flower only stamens or only pistils, not both.

Utricle, a small bladdery ovary wall.

Versatile, turning freely on its support, as an anther on its filament.

Whorled, arranged in a circle around an axis, as the leaves of some lilies.

Wings, the side petals of a papilionaceous flower.



Zygomorphic

Zygomorphic, having bilateral symmetry, as the corollas of many *Leguminosæ*.

INDEX

All names in italics are synonyms, — the preferred names are in Roman type